JAMES WATT

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BY

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"ROBERT BURNS IN OTHER TONGUES"
"LIFE OF BISMARCK," ETC.

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Dedicated

TO THE

VERY REV. R. HERBERT STORY, D.D., LL.D.,

PRINCIPAL,

AND TO THE SENATUS OF

The University of Glasgow

ON THE OCCASION OF ITS NINTH JUBILEE AND OF THE CENTENARY OF THE BIRTH OF STEAM NAVIGATION IN COMMEMORATION OF THE GREAT SERVICE RENDERED TO THE INDUSTRIAL DEVELOPMENT OF GLASGOW BY THE PROTECTION EXTENDED TO JAMES WATT BY THAT ILLUSTRIOUS AND VENERABLE INSTITUTION

PREFACE.

HAVING regard to the various exhaustive accounts of the life, character, and achievements of James Watt, I would feel it to be little short of impertinence to pretend to write the full story of his life. My object is to attempt to arrange and embody in a short and concise form from portions of his great career such details as may prove acceptable to the general reader, and to show him in the light of one of the greatest epoch-making men, whom

not only Scotland but the world has produced; for next to the invention of printing, perhaps no other invention has conferred a greater benefit or poured greater blessings on humanity than has the achievement of this modest but powerful and brilliant genius.

I have, therefore, aimed at so telling the story that general readers may understand him and his achievements, and appreciate the significance of his life. Students of his history will recognize my indebtedness to most of the authorities from whom I have quoted, but I have endeavoured to tell as much as possible in his own words or in those of his friends, using my own text as far as possible as a web in

which to weave such unimpeachable data.

From this point of view at least

"Who will may hear Sordello's story told."

WILLIAM JACKS.

CROSSLET,
DUMBARTON, *June*, 1901.

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CHAPTER I.

BEFORE AND AFTER.

THOSE who have been brought up enjoying the comforts of present-day facilities for travel, locomotion, and transport, must read with curiosity and interest, and it may be with some amusement, the description of such as existed in bygone days. One cannot take up a book relating to the general or social history of the eighteenth century and the antecedent period without being informed that the roads and means of locomotion in Great Britain were the worst in

Europe, that they were but tracks through marsh and moor, sometimes so ill-defined as to be indiscernible. Indeed wheel traffic was practically impossible. Travellers journeyed like Chaucer's pilgrims; light goods were carried like John Gilpin's famous bottles; and heavier articles, including corn and household goods, were transported on pack horses. Great difficulty was often experienced in getting even farm produce to market towns or seaports, and it not infrequently happened that corn and other farm produce, through inability to get them sent to a market centre, had to be given to the cattle. The dangers and difficulties of travel in the seventeenth century were appalling, and those of the eighteenth century

until towards its close were nearly as bad. For example, we read from reliable sources that in 1725, shortly before the birth of Watt, "Joshua Perry and Partners, belonging to the London Stage Coach, contracted for thretty pounds sterling to take Colonel William Grant and Patrick Duff, Esq., vetturino, from London to Edinburgh in a good closs bodyed coach and six horses, to travel in six days to York, to rest their two dayes, to travel in two dayes and a half to Newcastle, and in three or four dayes from that to Edinburgh as the roads will allow." Fourteen days for a distance which, since Watt's inventions, is done in eight and a half hours!!

In 1739 two Glasgow merchants,

John Glassford and Andrew Thomson, riding up to London on business, found the road north of Grantham to be nothing but a great swathe of clay-slough with a causeway in the middle,—so narrow that the riders had to plunge perpetually into the slough to make way for strings of packhorses. In 1742 Sir Dudley Ryder, most uxorious of Chief-Justices, sending his own coach from London to fetch his wife home from Bath, could only, with all his impatience, get his four great black horses (post horses were a later invention) to make the journey to and fro in eight days. In 1758 Wolfe, summoned hurriedly by Pitt for high American command, "leaving Exeter at five in the morning, was at midnight groping his way over

Salisbury Plain, and by noon was in London," 178 miles in 31 hours, "a rapidity little short of marvellous," says the chronicler; now it is done in a little more than four and a half hours by rail.

The stage coach which started to run between Edinburgh and Glasgow when Watt was at school in 1749 took twelve hours each way. Now the time is one hour and five minutes, and we grumble if we are ten minutes late.

A similar state of things existed on the sea. The coasting trade was carried on by luggers; they were good sea boats, but they sometimes spent a day or more in taking goods and passengers between ports such as Leith to those on the Fife coast. On the West coast the celebrated

fly boats occupied a similar position. Though considered paragons of swiftness, like the East-coast luggers they took a day or more to cover distances which are now done by steam in a few hours, sometimes by train in a few minutes. So late as 1750, the road from Glasgow to Dumbarton was so bad that manure was carried by boats from Glasgow to Scotstoun, only four miles down the river. It was better and cheaper to have two terminals and boatage than to cart even such a bulky article four miles. What a contrast between this and the hopper dredgers steaming with 1000 tons of sludge to the Cumbraes, depositing it in the sea and returning to the Broomielaw all in one day!!

With vessels for longer voyages such

as from Leith to London, the conditions were on the same lines. Take even the best means of transport, the famous Leith smacks, which our forefathers regarded much as we do now-a-days Macbrayne's fine steamers to the Western Highlands. They were plenteously advertised to sail for London with goods and passengers on certain fixed dates, and to keep the exact day, goods or no goods; yet in spite of this punctuality and boasted excellence, the voyages were long and comfortless, and it sometimes occurred that after two or three weeks at sea the smacks had got no further than Holy Isle. The voyage is now made in superbly appointed steamers "with all the comforts of the Saltmarket" and many more,—running with the greatest

punctuality and precision in thirty hours. In those days crossing the Atlantic was like going to another world, and fond farewells were taken as if the departing friend were starting on his last voyage to the "undiscovered country from whose bourn no traveller returns." Such a voyage is now regarded as a pleasure trip, taking some five or six days instead of an uncertain number of dreary and uncomfortable months.

This old order of things has now passed entirely away. We travel in the luxury of well-appointed carriages from Land's End to John o' Groats House; we cross Continents and span the desert, drawn as it were by horses of fire,

> "Like the steeds of the whirlwind
> If such there may be."

We cross the seas in defiance of opposing winds and tides, the very elements upon which we formerly depended; and but for the motion would imagine ourselves in a well-appointed hotel, and all this with a speed which even in Watt's time would have seemed miraculous, so thoroughly have space and time been abolished by the matchless power of one commanding mind.

The changes which have taken place in travel and transport are no greater than, if indeed so great as, those which have been brought about in other branches of industry. The feeble arm of man has been invested with a new force and power which in days a little earlier would have suggested supernatural agency. By this power earth's treasures are

brought from her depths to the surface; plains and valleys where solitude and silence reigned supreme have become resonant with the clang of Titanic hammers and musical with the deep hum of machinery; districts poor and dingy, barren and almost worthless, have become vast hives of industry and wealth. Seas have been chained together; continents so long separated have by the abolition of distance been enabled to shake hands with one another; over valleys and through the hearts of mountains messengers are now sent to proclaim that a new and mighty agent, a new apostle of civilization, has appeared upon earth. Foundries, forges, and engine-works have been created in a style till Watt's time unknown. Britain has been changed

from an almost exclusively agricultural to an almost exclusively industrial and manufacturing country. Thousands of her own and millions of the world's children now find employment and increased comfort in life. The times have gradually and visibly changed the conditions and character of labour; the interests and the habits of the people have undergone a great transformation, and the glory of a new era has been thrown over the industry and commerce of the Kingdom. What accounts for this change? Whence has it arisen? It was brought about by the great achievements of the most vigorous creative genius and clearest intelligence of the eighteenth century—James Watt.

CHAPTER II.

WATT'S PARENTAGE, BIRTH, AND YOUTH.

THIS remarkable man was born at Greenock on the 18th of January, 1736, so that "a blast o' Januar' win' blew hansel in on" the young Scottish scientist, as it did on the famous Scottish poet within a few miles distant from the same place some twenty-three years later.[1] Like Robert Burns, Watt was descended,

[1] Baptisms, not Births, were registered at that time; the facsimile of Watt's entry may be of interest (Fig. 1).

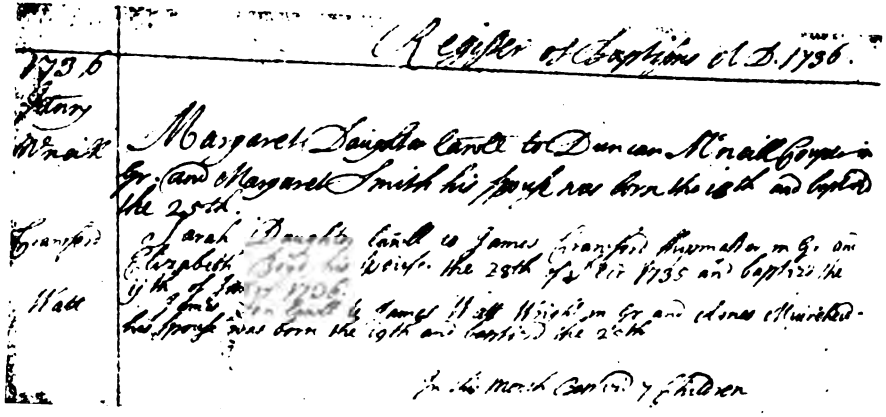

FIG. 2.—REGISTER OF WATT'S BAPTISM.

if not from wealthy parents, at least from a stock which, by honest living and lofty character, tends to preserve the nobility of the human race. His grandfather, Thomas Watt, was the first of the family who lived in Greenock. He was brought up on a farm near Aberdeen, and was a man of high principles and strong religious views. His father had been killed in battle fighting for the Covenanters against Montrose, and the victorious royalists pillaged and plundered the whole district, destroying the crops, seizing the cattle, slaying the inhabitants, and consigning their dwellings to the flames. Mr. John Spalding, in his *History of the Troubles and Memorable Transactions in Scotland in the reign of Charles II.*, says: "The country was left almost manless,

moneyless, horseless, and armless, so pitifully was the same borne down and subdued." Many of the inhabitants therefore sought shelter in less disturbed places.

Hence it was that Thomas Watt migrated to Cartsdyke or Crawfordsdyke, then a small village to the east of Greenock, but now incorporated in the extension of that enterprising and prosperous seaport. Cartsdyke was really then the seaport, with a pier and some small shipping facilities, none of which existed at Greenock, and here Thomas Watt set up a mathematical school. By his unswerving probity he steadily made his way, and became so conspicuous by his sound judgment and great good sense, that the Superior, Thomas Crawford of Cartsburn,

appointed him to be the Bailie of the Barony, and thus he became the most important person in the district next to the Superior himself. Besides his judicial function, it appears, by the records of the day, that he looked after the weights and measures, assessment for the poor, the collection of Government taxes, the minister's stipend, the schoolmaster's salary, the funds for repairing the kirk, bridge, and public clock, besides other multifarious duties. The kirk session,—an institution then strong in might and inquisitiveness,—found him, from the competence of his knowledge, his blamelessness in life and conversation, fit for high office, and ordained him an elder in the parish. This, and the other offices of a public

character, to which we have referred, he held for several years, and, when advancing age necessitated his resignation, the same august kirk-tribunal bore tribute on their minutes to the diligence and faithfulness with which he had discharged his trust. This revered patriarch died at the ripe age of ninety-two in 1734, and was buried

> "In Greenock churchyard
> On the banks of the Clyde,"

where his tombstone may still be seen, not very far from the spot where is also "mouldering now in silent dust, the heart" of Burns's Highland Mary.

He was survived by two sons, John and James, both settled in life and prosperous before the death of their father. The former had been trained

as a mathematician and surveyor. In the very year of his father's death he made the first survey of the Clyde, but as he died shortly afterwards, the map was eventually published by his illustrious nephew. The second son James was the father of the engineer, he had served his apprenticeship as a carpenter and shipwright at Cartsdyke, and was established in that trade on his own account at the time of his father's death. He did not confine himself by any means to his own particular vocation, but "put his hand to anything" which he felt he could do properly, and by which he could earn "an honest penny." He also had a general merchant's business, and, possessing the high qualities which distinguished his father, was at the birth of his famous son re-

garded as a man of substance and respected for his uprightness and integrity.

Such was the father; let us see the character of the mother of this famous man. Watt's father married Agnes Muirhead, his cousin, a woman distinguished by the brightness and goodness of her mind and heart, as well as by the graces of her person. She was of a cheerful temper and serene nature, was noted for her good sense and refined manners, and had an excellent knowledge of housewifery. Here is a proof of the trite saying, "The hand that rocks the cradle rules the world."

James, the only surviving child out of a family of five, was of a very delicate constitution, and required the continued care and nursing of

his mother all through his childhood. As was frequently the case in those days, when a feeling of self-reliance was more prevalent in Scottish families than it is now, Watt like many delicate or lame children was educated at home; his mother teaching him to read, and his father at night examining him as to his progress. The writer well recollects a similar experience of his own. Watt's father taught him writing and arithmetic; his mother, in order to interest him and prevent him from wearying, encouraged him to draw, while his father supplied him with a few tools from his carpenter's shop. These he soon was able to handle with much expertness. So true is it of Watt as of so many others who adorn humanity that "the child is father of the man."

As he thus necessarily lived much indoors, his nervous system became most sensitive, and a not very healthy sign was given by a precocity, which, as is well known, is often the result of disease. One or two instances of Watt's precocity are preserved. One day when only six years of age, a friend seeing him lying on the hearth marking it with a piece of chalk, said to his father, "You ought to send that boy to a public school and not allow him to trifle away his time at home." "Look how my child is occupied before you condemn," replied his father. It is said he was endeavouring to solve a problem in geometry. Another is the famous "tea-kettle" incident. His aunt, Mrs. Muirhead, an estimable lady, felt bound to reprove him for his conduct

at the tea table. "James Watt," said she, "I never saw such an idle boy as you are; take a book or employ yourself usefully. For the last half-hour you have not spoken one word, but taken off the lid of that kettle and put it on again, holding now a cup and now a silver spoon over the steam, watching how it rises from the spout, catching and counting the drops it falls into." M. Arago, the famous French professor and one of Watt's most eloquent eulogists, sees in this idle little boy the great engineer, preparing for the discoveries which were soon to immortalize him. There is nothing improbable in this poetic and pleasing suggestion, — a boy's "thoughts are long, long thoughts," —but Mr. Smiles thinks it unlikely, saying, "Nothing is commoner for

children than to be amused with such phenomena in the same way that they will form air bubbles in a cup of tea and watch them sailing over the surface till they burst. The probability is that little James was then quite as idle as he seemed." The reader must take his choice between these opinions, though I daresay most of us will be inclined to agree with Arago.

James was sent at last to Mr. M'Adam's school, where, as might have been expected, he was far from happy. Brought up as a tender flower in the domestic conservatory, he had little in common with the robust and wild-spirited lads with whom he was then thrown into contact, and became the butt upon whom both boys and girls expended their

ill-humoured wit. Nor were his unpleasant experiences in the playground compensated by pleasure in the class. He was void of the power of acquiring knowledge superficially, and was considered dull and backward amongst pupils of his own years. But when, about thirteen, he was put into the mathematical class his latent powers sprang into activity, their development was rapid, and his progress great. His chief education, as I have said, was at home, where his father explained to him the books he read, embellishing the entertainment with tales of the trials of the Covenanters and similar subjects. Bunyan, Boston, Blind Harry's *Life of Wallace*, old ballads, he read and re-read, and before he was fifteen had more than once carefully perused

S'Gravande's *Elements of Natural Philosophy.*

About this time he was taken to Glasgow for a change. Here he developed such a wonderful aptitude for telling stories that Mrs. Campbell, the relative with whom he stayed, begged his father to take him away. "I cannot," said this worthy lady, "stand the excitement he keeps me in. I am worn out for want of sleep. Every evening before retiring to rest he contrives to engage me in conversation, then begins some striking tale, and whether humorous or pathetic the interest is so overpowering that the family all listen to him with breathless attention, and hour after hour strikes unheeded."

Returning to Greenock he was sent to the Grammar School, where

he studied the rudiments of Greek and Latin, in which he made satisfactory progress. Mathematics was still, however, the study in which he excelled and in which his strength clearly lay. It was at home, nevertheless, that the course of his real education was being carried on. A high and lofty character was being formed by the example and influence of his excellent parents. He watched the operations of his father's workmen, and gained considerable skill in using his hands and tools, gradually acquiring those habits of industry and perseverance, and the faculty of invention which afterwards so conspicuously marked his career. He had a small forge and bench fitted up for his own use. He spent his time in drawing, carving, constructing many

ingenious models, chiefly of things he saw in his father's works, such as miniature cranes, pumps, capstans, etc., and it was a common saying amongst the workmen that "little Jamie had gotten a fortune at his fingers' ends." We are told that the kind of work which most attracted him was that connected with nautical instruments, such as ships' compasses, quadrants, etc., and it was decided that he should follow the trade of a mathematical instrument maker.

When in 1754 he reached the age of eighteen, he was sent to Glasgow to learn this business. Glasgow was then a very modest place, though her population had rapidly increased since the union of Scotland and England. The census showed in 1763 a population of only

28,200 inhabitants. There were two main streets in which were good and even some stately buildings, but the bulk of the houses had wooden fronts and low thatched roofs. The city was devoid of pavements, had neither newspaper nor police, and nothing but the lightest shallop could ascend by river further than Port-Glasgow. There was no such personage as a mathematical instrument maker within St. Mungo's walls, and Watt had great difficulty in finding a teacher. The nearest approach to what he desired was an ingenious mechanic who traded as an "optician," but the designation seems to have been the most dignified part of this worthy's trade. He repaired and sold spectacles and drawing instruments and also

made fishing rods and tackle—being, in short, a kind of "Tammy a' things." Watt was as dexterous at dressing flies, making fishing rods, and even musical instruments, as he had been at repairing quadrants, compasses, etc., but he and his friends, feeling that this was not the way to become a mechanical instrument maker, decided on the strong recommendation of Professor Dick, of the Glasgow University, to send him to London. So, provided with a letter of introduction from the professor, he started for the capital on the 7th June, 1755, where he arrived on the 19th, having taken twelve days for the journey. There being no stage coach or other ready mode of conveyance between Glasgow and London, as was seen

in our first chapter, young Watt made the journey on horseback *via* Coldstream and Newcastle, accompanied by a relative, Captain Marr, who was on his way to London to join his ship. His "chist" had been sent by sea, and his father's memorandum book contains the following entry, dated 6th June, 1755, the day before his son's departure:

> "To send James Watt's chist to the care of Mr. William Oman, Ventener in Leith, to be shypt for London to ye care of Captain William Watson, at the Hermitage, London. Pd. 3s. 6d. for wagon carage to Edenbrough of chist. Pd. to son James £2 2s. Pd. Plaster and Pomet, 1s. 4d. Pd. 4 doz. pencels, 1s. 6d."

Worthy, methodical old gentleman, his various cash entries throw a world of light upon his son's life

and upon life in general in those days.

Captain Marr at once set about placing his youthful friend under some mathematical instrument maker, but here an unexpected and what seemed an insurmountable difficulty presented itself. The rules of the trade were that anyone employed as a journeyman must have served an apprenticeship of seven years, which as we know young Watt could not possibly claim to have done, and he had no intention of spending such a length of time in this way, nor indeed would his circumstances permit him to do so. Accompanied by the faithful and persevering captain, he went from shop to shop

> "To beg a brother of the earth
> To give him leave to toil."

Here also the poor petitioner was spurned. He met with nothing but rebuffs, and wrote to his father after some weeks' efforts, "I have not yet got a master; we have tried several, but they all made some objection or another. I find that if any of them agree with me at all it will not be for less than a year, and even for that time they will be expecting some money." In spite of these disappointments, the youthful seeker after work kept "aye a heart abune them a'," and eventually offered to work gratuitously for a watchmaker, a Mr. Neale, with whom the captain had done business. Allowed to work for nothing, which he preferred doing to not working at all, he was set to cut letters and figures for clocks, etc., from which

he certainly could learn little. At last an opening was secured for him with a well-known and respectable mathematical instrument maker, John Morgan by name, whose shop was in Finch Lane, Cornhill, where it was agreed he should receive one year's instruction, for which he should pay a fee of twenty guineas and give the whole proceeds of his labour. Once at this congenial employment, he made rapid progress. Starting with parallels, rules, scales, and parts of ships' quadrants, he could, by the end of the first month, finish a Hadley's quadrant better than any other apprentice in the shop, and most probably than any journeyman; and at the end of the year he wrote to his father giving an account of what instruments he had made, and

expressing the desire and hope soon to be able to relieve his parent from the expense of keeping him. Indeed, he already tried to get work to which he could attend at night, and thus help at least to keep himself. He lived on eight shillings per week, and we can well believe, as he wrote to his father, that he could not reduce that amount "without pinching his belly."

There is much that is pathetic in the picture of this highly-strung, nervous youth, weary in body and mind with his day's work, and racked with headaches, struggling to assist in maintaining himself, and relieve his parents of a burden.

His health threatened at last to give way entirely. The conditions of his work did not tend to improve

it, and he became so depressed in spirits that he determined, with his father's consent, to return to Greenock to re-establish his health in his native air. With his father's aid he purchased some useful tools and material, also Bion's book on the construction and use of mathematical instruments, and arrived in Greenock in the autumn of 1756. The fresh air and thoughtful care enjoyed at home soon restored him to his former strength, and he proceeded for the third time to Glasgow to commence business on his own account as a mathematical instrument maker, being now about twenty years of age. Here again unexpected difficulties met the struggling youth. It is wonderful how prone the malice or thoughtlessness of little minds is to try to

stop the progress of those more talented than themselves. There was not a single mathematical instrument maker in Glasgow; the establishing of such an one would have been a positive boon, but even such a respectable body as the Corporation of Hammermen discovered that Watt spelt its shibboleth without the h. He had neither served a seven years' apprenticeship nor was he the son of a burgess, and so he was prevented from commencing business. He then applied to the Corporation of Glasgow for permission to use a small workshop for experimental work, but town and city corporations have their pompous dignity to look to, and Glasgow met poor Watt's appeal by a peremptory rejection. So far, therefore, as these two bodies were

concerned, the development of the use of steam, with its untold benefits, might have been delayed a generation or more. It is well for the cause of progress that the influence and power of the manly and the noble outweigh those of the mean and petty, and so it happened here. Young Watt had repaired some mathematical instruments for Dr. Dick, Professor of Natural Philosophy in the University, to whom I have already referred, who, recognizing the skill of the young mechanic, induced the professors to give him a room within the college walls, where their authority was supreme. Thus Watt secured his end, Hammermen and Corporation notwithstanding, with the additional title of Mechanical Instrument Maker to the University.

Within the walls of the ancient University[1] Watt had a workshop on the first floor and a shop for selling his own productions and other articles on the ground floor. He worked diligently and lived frugally, but still had difficulty in making ends meet; indeed, did not succeed in doing so, as we occasionally still meet with memoranda of James, "Sent to son James by his father," to whom he wrote at the end of the first year's trading, "Unless it be the Hadley instruments there is little to be got by it, as at most other jobs I am obliged to do the most of them myself, and as it is impossible for one person to be expert at every-

[1] I speak of course of the old building in High Street, the site of which is now occupied as a goods station by the North British Railway Co., not far from the Cathedral. See Fig. 3.

thing, they often cost me more time han they should do." The quadrants did not sell rapidly. Watt had not self-confidence and push enough to secure orders; he was in need of what he afterwards secured to such a remarkable degree in his partner Boulton, someone who would be the complement of himself, and who would have undertaken the distribution of his instruments among the public. We find him shortly afterwards writing to his father, "If this business does not succeed, I must fall into some other."

He now added map and chart selling to his business, and amongst these he advertised the first map of the River Clyde, surveyed by his Uncle John, to which I have already referred. The *Glasgow Courant* con-

tained the following advertisement on the subject:

Just published

and to be sold by James Watt at his shop in the College of Glasgow, price 2s. 6d., a large sheet map of the River Clyde from Glasgow to Portencross, from actual survey.

To which is added

a Draught of part of the North Channel with the Firth of Clyde according to the best authorities.

He experimented in various things, which all proved unprofitable, and, no doubt remembering the policy of his first master, the optician, took to making musical instruments, with which, although he had no ear for music, he was most successful, eventually producing several organs, some of which still exist amongst Glasgow antiquities.

At this time he made several

valuable acquaintances, the friendship of many of whom remained through life. When he visited his club (the Anderston Club), he there met Mr., afterwards Professor Millar, Dr. Robert Simpson, the mathematician, Adam Smith, Dr. Cullen, Dr. Black the discoverer of latent heat, and others. The counsel and friendship of the great chemist, Dr. Black, was of the highest value to Watt all through life, and the letters of the two friends are peculiarly interesting. Watt endeavoured to obtain as much instruction as possible by his intercourse with these distinguished men. As he modestly said many years later, "Our conversations then, besides the usual subjects with young men, turned principally on literary topics, religion, morality, belles-lettres, etc.,

FIG. 3.—GLASGOW UNIVERSITY (HIGH STREET).

and to those conversations my mind owed its first bias towards such subjects, in which they were all much my superiors, I never having attended a college, and being then but a mechanic." These gentlemen seemed equally taken by the modest bearing, keen powers of observation, and evident genius of their young acquaintance, and his shop was frequently visited by them as also by his old friend Professor Dick and Professor Anderson, afterwards founder of the College in Glasgow, which still bears his name. His shop became a kind of howff for these then young men, many of whom have written their names so brilliantly on the firmament of fame. I must not forget another acquaintance made by Watt at this

time, a student at the College, John Robison, who became Professor of Natural Philosophy in Edinburgh, of whose intercourse with Watt it may be truly said, "Iron sharpeneth iron, so a man sharpeneth the countenance of his friend." We owe a great deal of our knowledge of Watt to this friend, and as we have seen Watt's appreciation of these companions, we learn from Robison how he in turn was regarded by them. After informing us that Watt rapidly came to be looked upon as the ablest man about college, he says: "When to the superiority of knowledge of his own line, which every man confessed, there was joined the naïve simplicity and candour of his character, it is no wonder that the attachment of his

acquaintances was so strong. I have seen something of the world, and I am obliged to say that I never saw such another instance of general and cordial attachment to a person whom all acknowledged to be their superior. But this superiority was concealed under the most amiable candour and liberal allowance of merit to every man. Mr. Watt was the first to ascribe to the ingenuity of a friend things which were very often nothing but his own surmises followed out and embodied by another. I am well entitled to say this, and have often experienced it in my own case." With these intimate friends he often discussed the question of the future of the steam engine, and counselled by them made certain experiments, but his

enthusiasm was not fairly awakened until in 1764 he was given a model of Newcomen's engine, belonging to the University, to repair (see Fig. No. 4). This engine, though the most advanced type of the day, was a clumsy affair, and so expensive to work that it was not in much use, and when used at all was only used for pumping water, the drainage of mines, and such like.

Watt, whose busy and inventive brain was never satisfied with his own work, and was always seeking to find improvement in the work of others, set himself earnestly to developing and perfecting the steam engine. It must not be thought that he confined himself to this work alone, but I propose to follow it instead of dealing with other em-

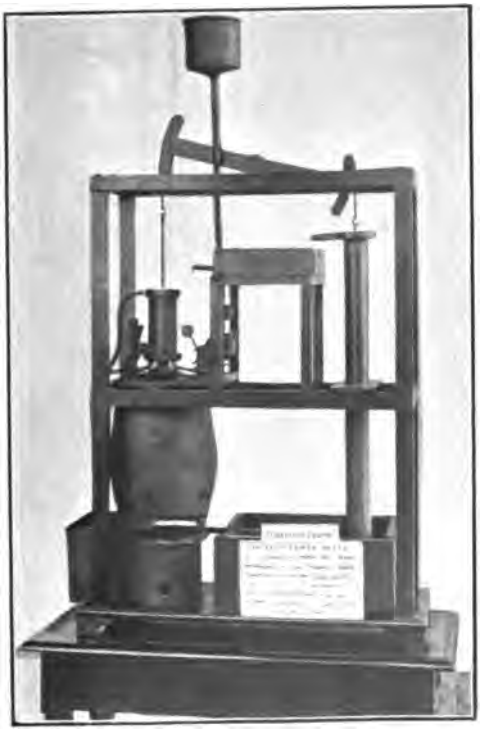

FIG. 4. -NEWCOMEN'S ENGINE.

ployments, as it was this achievement which secured his unique niche in the temple of fame and conferred untold benefits upon the world. Here, however, I must make a short digression. It is a pretty general delusion that we owe the discovery of the power of steam itself to Watt. This of course is not so, and I will briefly trace the history of the steam engine up to the lucky day when Watt was set to repair the model of Newcomen's engine at the University of Glasgow.

CHAPTER III.

THE STEAM ENGINE BEFORE THE DAYS OF WATT.

THIS part of my subject must be expressed very briefly, and I will therefore only state the dates and names of the "seekers after science," and in a word or two note the peculiarities of their discovery.

So far from this great force being a discovery of the eighteenth century, or even of modern times, some notion of it was known in Egypt some 200 years B.C. to a celebrated mathematician, Hero, of Alexandria.

His method seems, however, to have been rather that of a heat engine than a steam engine. For this he employed a jet of steam in his first apparatus; in the second he drove the water from one vessel to another by means of heated air. Like so many of the splendid achievements in art and science in that extraordinary ancient country, the knowledge of Hero's scheme seems to have been also lost, and the steam engine does not practically reappear for 1800 years. After that long slumber we find Giovanni Battista della Porta of Naples[1] in 1601 publishing a treatise on Pneumatics. He describes an apparatus somewhat similar to Hero's, but with the

[1] To this ingenious man we owe the discovery of the camera obscura.

important difference of substituting a steam jet instead of Hero's air or water jet, and he also describes the formation and use of the vacuum by condensation. Indeed, his discoveries are almost those which a century later Savery developed into a commercially successful steam engine. Porta was quickly followed by Solomon de Caus in 1615. The further development made by him was the discarding of the two vessels with hot and cold water, used by Porta, and substituting one vessel and hot water only (see Fig. 5). He again was followed by Giovanni Branca in 1629, who returned to the jet of steam theory, which, however, was discarded and the trend of the development of steam power continued on the lines of Porta and Caus.

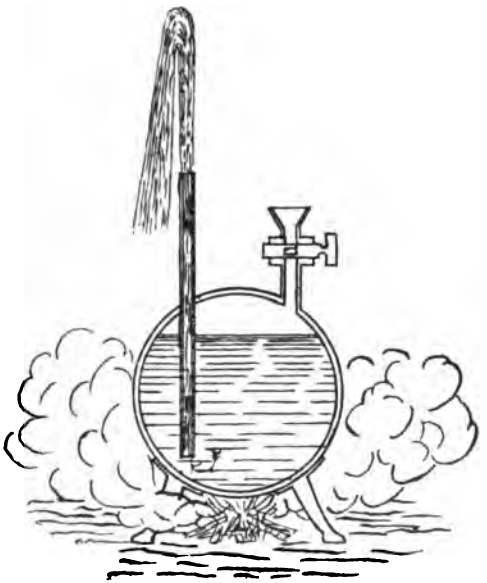

FIG. 5.—DE CAUS' ENGINE.

In 1681 Dr. Papin, of Digester fame, a protestant refugee from France, and a pupil of Huygens, following the gunpowder idea, after various experiments came to steam, and in 1690, in a celebrated paper entitled "A new method of obtaining very great moving powers at very small cost," he wrote, "I felt confident that machines might be constructed wherein water, by means of no very intense heat, and at small cost, might produce that perfect vacuum which had failed to be obtained by means of gunpowder." He actually succeeded in making engines to drain the mines in Westphalia (having been previously installed as Professor of Mathematics at Marburg, Germany, whither his fame had spread), but the progress

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Attention seems now to have been fairly roused to the utility and importance of steam power, and in 1663 the Marquis of Worcester made what seemed to be the first steam engine really put to use. No complete description or plans are extant, though it is supposed to have been on the lines of Della Porta, but to have shown the further development of separate boiler and a pair of displacement chambers.

In 1678 Jean Hautefeuille suggested the use of the piston in the tubes, practically piston and cylinder, which had long been used in pumps, and in 1680 the celebrated Professor Huygens advocated the piston principle, using gunpowder to cause the vacuum and allowing atmospheric pressure to press down the piston.

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was slow, as can readily be understood when we know that to cause condensation he did not apply cold directly, but took away the fire. One great improvement was invented by him, however, and that was the safety valve, applied to the vessels in which he boiled the animal substances for his Digester where he required great heat, so as to prevent their explosion. Thus gradually was brought to light by the fertility and power of brain of these various seekers after knowledge the most important agents in the formation of the modern steam engine.

These varied agents were grasped in 1698 by a strong hand, that of Captain Thomas Savery, a military officer born at Shilston, near Modbury in Devonshire, who succeeded in producing the first really practi-

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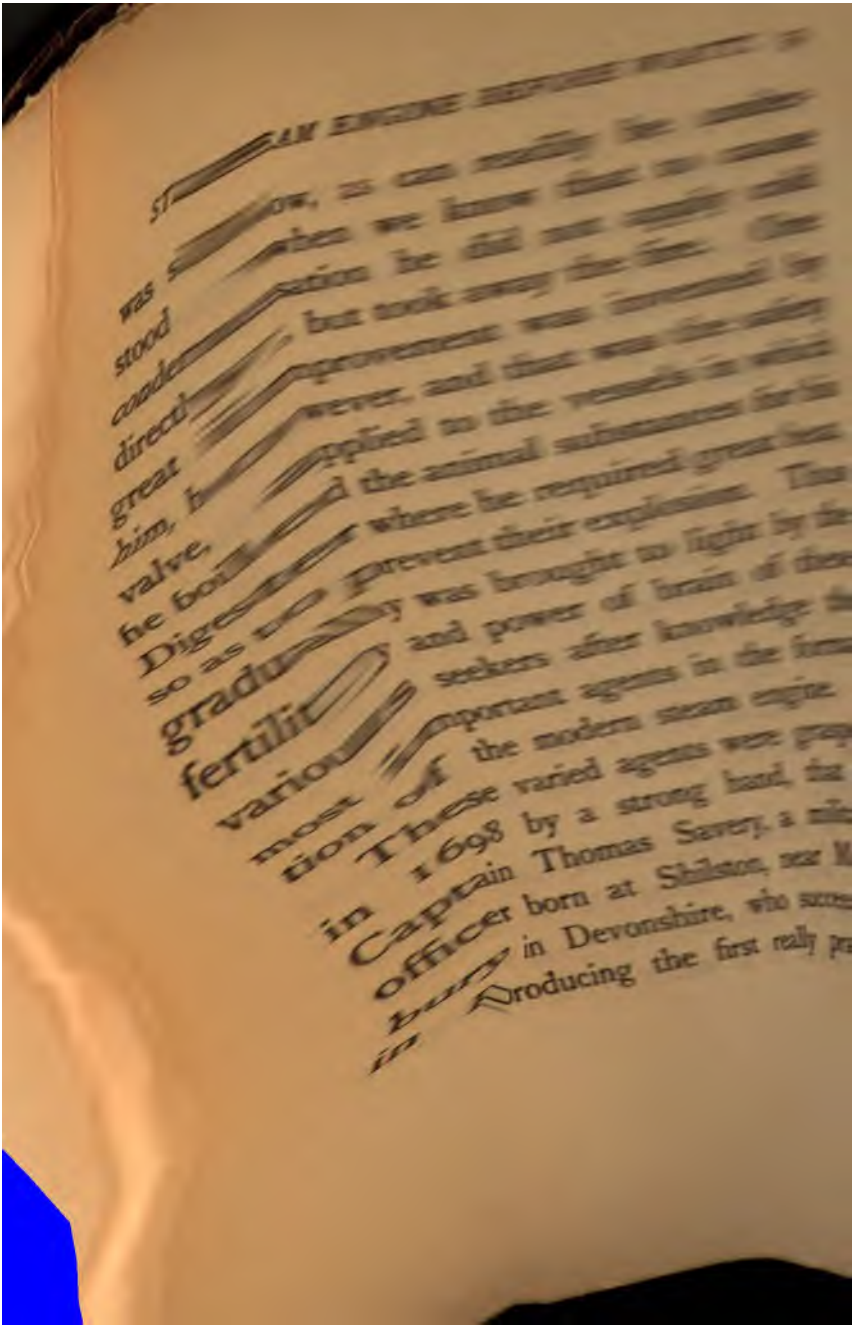


regulator towards you, by which means you will stop the steam-pipe O1, so that no more steam can yet come into the receiver P1, but you will open a way for it to pass into O2, and by that means fill the other receiver P2 with the steam, as the other was before.

"While this is doing, let some cold water be poured on the first-mentioned receiver P1, by which means the steam in it being cooled and condensed, and contracted into a very little room, and consequently pressing but very little (if at all) on the valve or cock R1, at the bottom of the receiver P1, there is nothing there to counterbalance the pressure of the atmosphere on the surface of the water in the lower part of the sucking pipe T, wherefore it will be

pressed up, and ascend into and fill the receiver P1, driving up before it, as it rises, the clack or valve R3, which, afterwards falling down again and shutting close, hinders the descent of the water that way.

"Then (the receiver P2 being in the meantime emptied of its air) push the handle of the regulator from you, and the force of the steam coming from the boiler will act upon the surface of the water contained in the receiver P1, where it forces or presses hard upon it, and still increases its elasticity or spring until it exceeds the weight of the column of water in the receiver and pipe S, which then it will necessarily drive up through the passage QR, 1 QQ, into the force-pipe S, and at last discharge it out at the

top as it is represented in the figure.

"After the same manner, though alternately, is the receiver P2 filled and emptied of water, and by this means a regular stream is kept continually running out at the top of the force-pipe S, and so the water is raised very easily from the bottom of the mine, etc., to the place where it is designed to be discharged,

"Only I should add that after the engine begins to work, and the water is risen into and hath filled the force-pipe S, then it fills also the little cistern X, and by that means feeds the pipe YY, which I call the condensing pipe, and which can be turned sideways over either of the receivers, and will then be open; by this cold water is con-

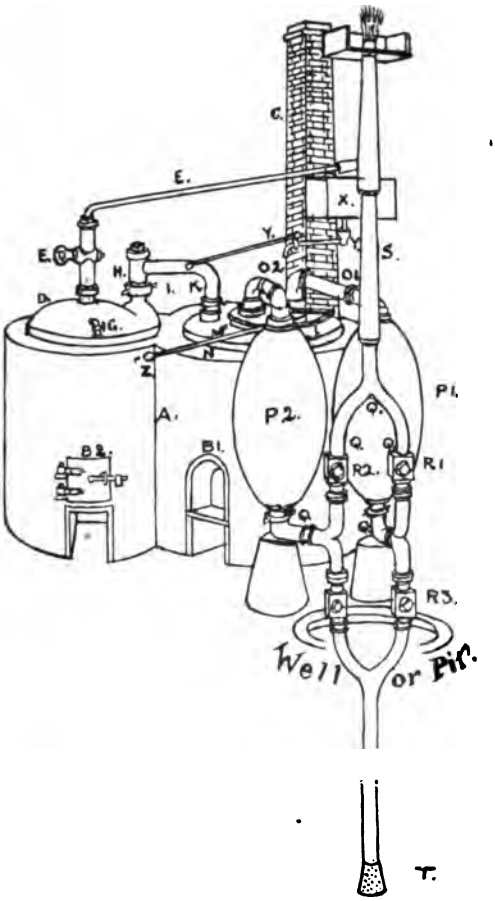


FIG. 6.—SAVERY'S ENGINE.

veyed down from the force-pipe to fall upon the outsides of the receivers when thoroughly heated by the steam, in order to condense the steam within, and make them suck (as it is usually called) the water out of the well up into the receiver.

"Also a little above the cistern goes the pipe E, to convey water from the force-pipe into the lesser boiler D, for the purpose of replenishing the great boiler L, when the water in it begins to be almost consumed. Now, when there is need of doing this, turn the cock E, so that there can be no communication between the force-pipe S and the lesser boiler D; and putting in a little fire under the small boiler B2, the water will there grow presently

hot; and when it boils, its own steam, which hath no vent out, pressing on its surface, will force the water up the pipe H, through K, into the great boiler L, and so long will it run till the surface of the water in the boiler D gets to be as low as the bottom of the pipe H, and then the steam and water will run together, and by its noise, and rattling of the clack I, will give him that works the engine sufficient assurance that the small boiler hath emptied and discharged itself into the greater one L, and carried in as much water as is then necessary; after which, by turning the cock E again, you may let new cold water out of S into the lesser boiler D, as before, and thus there will be a constant motion and a continual supply

of the engine without fear of decay or disorder.

"Also, to know when the great boiler wants replenishing or not, you need only turn the gauge-cock N, and if water come out there is no need to replenish it, but if steam only come you may conclude there is want of water; and the like will the cock G do in reference to the lesser boiler D, showing when it is necessary to supply that with fresh water from S; so that, in working the engine there is very little skill or labour required; it is only to be injured by either a stupid or wilful neglect."

Savery's engines were used to pump water into reservoirs, into cisterns for houses, and for similar purposes, but the engineer's ambition was to clear drowned-out mines and such as were

so deep as to be hampered by water. For this he proposed to raise the water by engines placed at different depths, one above the other, so that by three lifts of 80 feet the water might be brought up 240 feet,—the same principle which on a smaller scale has been employed in working the S'hadoofs in Egypt by hand, to lift the waters of the Nile for the irrigation of the broad and fertile fields in that interesting valley. Some of these engines were actually used, and seemed at first to do fairly well, but the pressure of steam required for the work was so great as to cause frequent explosions, and often the whole mechanism was blown to pieces. Bradley says of one of the last of these, "It was liable to so many disorders if a single mistake happened

in the working of it, that at length it was looked upon as a useless piece of work and rejected." For these reasons Savery's engines, great as was their advance, were discarded in favour of the most perfect engine made until that of Watt. This was the engine of Thomas Newcomen, also a Devonshire man, an ironmonger who, in conjunction with David Cawley, a glazier, studied the various descriptions of Worcester, Papin, and Savery, producing an engine the model of which, as we have seen, first set the subtle and powerful brain of Watt working on the great subject. Newcomen obtained his patent in 1705, and it was found so superior that, with various improvements by Smeaton and others, it held the

field for nearly three-quarters of a century.

I do not propose to give here a long description of this engine, as I shall have to refer to its details in describing Watt's improvement, but it is desirable again, as with the others, to point out the steps which had been taken by its construction in the advancement of the "New Force." His master, Dr. Hook, whilst dissuading Newcomen from wasting time on the construction of an engine on the principles hitherto adopted, is said to have remarked, "Could he" (probably referring to Papin) "make a speedy vacuum under your piston, your work were done." This suggestive remark set Newcomen on the right lines, adopting neither those of Papin by extract-

ing the air, nor Savery's of creating a vacuum by condensation in a closed cylinder. He made a kind of combination, and secured a vacuum by the condensation of steam, but, instead of employing the closed cylinder of Savery, adopted Papin's cylinder, fitting it with a piston. On this principle he experimented for years, and at last constructed a model and secured his patent as stated above. The engine has been described thus:

"The steam was generated in a separate boiler, as in Savery's engine, from which it was conveyed into a vertical cylinder underneath a piston fitting it closely, but movable upwards and downwards through its whole length. The piston was fixed to a rod, which was attached by a joint or a chain to the end of a lever

vibrating upon an axis, the other end being attached to a rod working a pump. When the piston in the cylinder was raised, steam was let into the vacated space through a tube fitted into the top of the boiler, and mounted with a stop-cock. The pump-rod at the further end of the lever being thus depressed, cold water was applied to the sides of the cylinder, on which the steam within it was condensed, a vacuum was produced, and the external air, pressing upon the top of the piston, forced it down into the empty cylinder. The pump-rod was thereby raised, and the operation of depressing and raising it being repeated, a power was thus produced which kept the pump continuously at work."

Though different from and superior

to Savery's, it was still a crude production, and worked slowly until two accidents or, more properly speaking, incidents, like the falling of Newton's famous apple, led to its great improvement. The first defect of the engine was the slowness of condensation, which can easily be imagined when we know that this was obtained by throwing cold water on the cylinder, which not only cooled the cylinder, as was desired, but fell upon the boiler placed directly under it, and cooled it also, which was certainly not desired. Then the inventors surrounded the cylinder with cold water, which was "out of the frying pan into the fire," as it cooled the cylinder so much that it interfered with the power of the steam. Happily the first accident soon occurred, which suggested a

way out of the difficulties. In order to keep the piston air tight a piece of cloth or leather was fitted round the head of the piston, and to make "assurance doubly sure" some water was also kept on the head of the piston. One day the engineers were surprised at the piston making rapid strokes in succession, and on examining the cause found that a drop of water was coming through a defect in the cloth. Quick to grasp the meaning of this teaching of nature, Newcomen at once threw aside the outside cooling of the cylinder and employed a jet of water into the cylinder itself, a primitive injection pipe, by which the condensation was at once effected, and the piston drawn down by the atmospheric pressure with marvellous rapidity.

The second accident was due to the ingenuity of a boy. Two boys were employed, one to turn the cock to let in the steam, the other to turn the cock to let in the condensing jet of cold water. Now, one of these lads, evidently an observant and ingenious youngster, by name Humphrey Potter, had observed that the beam rose and fell alternately with great regularity, and, wishing to be relieved from the easy but constant task of opening and closing the cocks, managed by a rude arrangement of clutch and string to fasten the levers which moved the two cocks to the beam. This worked in so satisfactory a manner that he could enjoy his play at will, for no doubt it was play he was about as he christened his arrangement the "Scoggan," a word

derived from "scogging," employed in the North to express shirking of work. So, by the ingenuity of a boy bent on play, another great improvement had been discovered by which the strokes of the piston were increased from 6 or 8 to 15 or 16 in the minute. Thus gradually Newcomen's engine, by the combined ingenuity of many minds, attained its usefulness. Great inventors devoted attention to its perfection, amongst others Brindley and Smeaton, the latter of whom brought it to its point of excellence. His great Chacewater engine remained without a rival until Watt appeared, to whose labours after this necessary digression I now return.

CHAPTER IV.

THE STEAM ENGINE UNDER THE HANDS OF WATT.

THE great drawback to Newcomen's engine was the enormous quantity of fuel required to keep up steam, and even with this it occasionally failed. Watt, as soon as he had turned his attention to steam, studied everything that had been written on the subject upon which he could lay hands, and was conducting his own experiments when he received the model of Newcomen's engine. He regarded it at first, he said, as "a fine

especially scientific greatness, he afterwards wrote "that when it was analysed, the invention would not appear so great as it seemed to be. In the state in which I found the steam-engine it was no great effort of mind to observe that the quantity of fuel necessary to make it work would for ever prevent its extensive utility. The next step in my progress was equally easy—to inquire what was the cause of the great consumption of fuel; this, too, was readily suggested, viz., the waste of fuel which was necessary to bring the whole cylinder, piston, and adjacent parts from the coldness of water to the heat of steam, no fewer than from fifteen to twenty times in a minute."

There can be no doubt that Watt's

whole being was engaged in thinking out the problem. "My whole thoughts," he wrote to a friend, "are bent on this machine. I can think of nothing else." As the reader will recollect, condensation was caused in Newcomen's engine by a jet of water being thrown into the cylinder, but before the vacuum could be formed the heat of the cylinder must fall to 100° or less, and therefore before the steam could again force up the piston, the cylinder required to be again heated up to 212°; hence the enormous loss of steam and ruinous cost of fuel. Watt's first step towards his great discovery was his arrival at the conviction that by some means or other the heat of the cylinder must be constantly kept up to 212°, the heat

at which the steam was introduced, but how to do this and yet get a temperature of 100° which was required for every stroke of the piston —this was the problem Watt was employing his powerful and inventive brain to solve. Many descriptions are given as to how and when "this capital improvement flashed upon his mind and filled him with rapture." I prefer to tell the story in his own words, as indeed I shall do wherever possible in this narrative:

"I had gone to take a walk on a fine Sabbath afternoon. I had entered the Green by the gate at the foot of Charlotte Street, and had passed the old washing house. I was thinking upon the engine at the time, and had gone as far as

the herd's house[1] when the idea came into my mind that as steam was an elastic body it would rush into a vacuum, and if a communication were made between the cylinder and an exhausted vessel, it would rush into it, and might be there condensed without cooling the cylinder. I then saw that I must get rid of the condensed steam and injection water if I used a jet, as in Newcomen's engine. Two ways of doing this occurred to me. First, the water might be run off by a descending pipe, if an off-let could be got at the depth of 35 or 36 feet, and any air might be extracted

[1] Yes, Mr. Watt, very candid of you, but it was lucky, indeed providential, that the Kirk seizers did not haul you up for walking and thus breaking the Lord's day, as was their wont in those rigid days of at least professed godliness.

by a small pump. The second was to make the pump large enough to extract both water and air. . . . I had not walked further than the Golf-house when the whole thing was arranged in my mind."

Next morning he was up betimes, and, as usual with all his thoughts and theories, he started to give them practical form in the shape of a model. With a borrowed large brass syringe for a cylinder, a cistern of tinned plate pressed into service as the first separate condenser in the world, and with pipes and pumps in keeping with these rude implements, the great experiment proceeded, the success of which had the tremendous results elsewhere detailed. Let us hear Watt's modest description:

"When once the idea of separate

condensation was started all these improvements followed as corollaries in quick succession; so that in the course of one or two days the invention was thus far complete in my mind."

Yes, the invention was complete, the most important of all, with its untold uses and its unmistakable lessons; as Professor Jardine said: "The last step of all was the most difficult—the forming of the separate condensing vessel. The great knowledge Mr. Watt had acquired of the mechanical powers enabled him to construct it, but I have often heard him say this was a work of great difficulty, and that he met with many disappointments before he succeeded. I have often made use of this beautiful analysis received from Mr. Watt,

in another department in which I have been long engaged—to illustrate and encourage the progress of genius in youth—to show, that once in possession of a habit of attention, under proper direction, it may be carried from one easy step to another, till the mind becomes qualified and invigorated for uniting and concentrating effort—the highest exertion of genius." But although the invention was complete, the engine was far from being so. In Newcomen's atmospheric engine steam was used only to raise the piston, the weight of the atmosphere on the top pressing it down after condensation had been effected in the manner already described, but with this drawback that the cylinder was cooled. Watt after again pondering and experi-

menting inserted the steam at the top to drive down the piston. Newcomen's engine also lost heat by radiation. Watt enveloped his, not only in non-conducting materials, such as wood, etc., but enclosed the cylinder within another to prevent the loss of heat. He also added various other improvements; for instance, Newcomen's cylinder was open to the air, and the piston top made steam-tight by a layer of water on the top; Watt covered it in, leading the piston-rod through a stuffing box on the top of the cylinder, made steam-tight by fat or oil, allowing steam instead of air to press on the piston top—all based upon the purpose and desire of keeping the cylinder constantly up to the normal heat, so that step by step

the character of the engine became entirely transformed from one chiefly worked by the atmosphere (as its name implied) to a real steam engine in which steam was the sole power factor.

Watt's difficulties seemed only just beginning, one of the greatest being to get workmen sufficiently skilled to make the various pieces of his machine, and when, after several weeks' close attention and labour, he had his engine ready it showed distracting defects. The piston let in the air; how could it fail to do so when no appliance existed to bore out a cylinder, and which therefore had been hammered? Leakages were sputtering all over, and various parts were far from satisfactory; but the crowning fact was that the principle

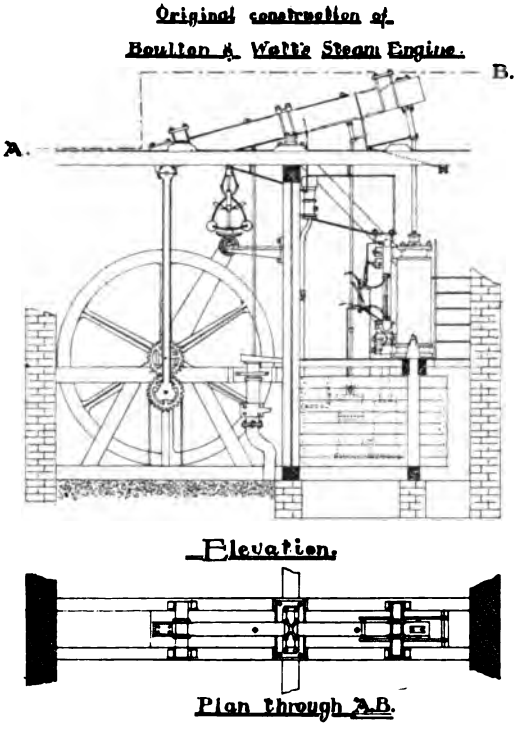
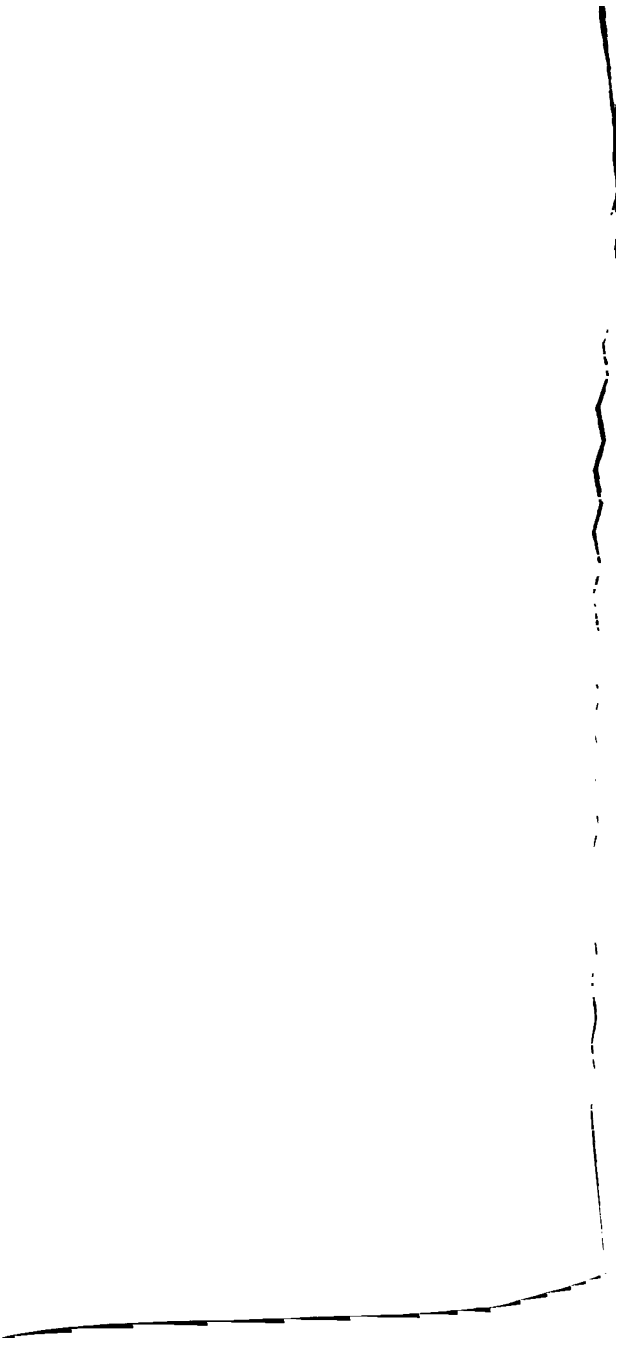


FIG. 7.—BOULTON AND WATT'S ENGINE.



of the great invention and of the various improvements was established. Though naturally cast down and disappointed by the failure of so many parts of the mechanism, Watt set himself to remedy the defects with all the assiduity and perseverance of his calm but determined nature. But to make these engines required capital, which he did not possess; indeed, his recent exertion in this way had involved him in debt, and the Glasgow merchant princes, a class now beginning to come into evidence, either had no money to spare or had not sufficient confidence in the financial success of the enterprise. Again his friend, Dr. Black, who had been all along deeply interested in Watt's labours, came to his aid. He had assisted the

inventor from his own means, but these being too limited to meet the enterprise, Black introduced the young engine builder to Dr. Roebuck, the founder of the famous Carron Works, a singularly able man, not afraid to face difficulties nor to lay out his money in a promising enterprise. Dr. Roebuck agreed to take an interest in the engine venture, and so Watt was again sent on his career with an "Ich heiss euch hoffen."

CHAPTER V.

WATT AND ROEBUCK. WATT AS CIVIL ENGINEER.

Dr. Roebuck, who was sinking some coal pits near Bo'ness (then Boroughstoness or Borrowstoness), experienced great difficulty with the water, and Newcomen's engine, which he had erected, though the best then known, was unable to cope with it. He therefore eagerly listened to Dr. Black's tale of the new engine so superior to Newcomen's both in economy and performance. Though doubtful of the principle, he eventually had his doubts

removed, and agreed to find sufficient means, receiving two thirds and giving Watt one third of the profits, and on the faith in its success cheerfully advanced considerable sums of money. The arrangement was made in the autumn of 1765, and Roebuck, with his energy of character, urged Watt to push on with the engine. Trials and trials were made with varying success, requiring various improvements. He had difficulty in getting reasonably good workmen; he was afraid of others seeing the work and forestalling him by taking out a patent, his own not being taken out until 1769. Like another great heart in ancient days, he was "perplexed but not in despair . . . cast down but not destroyed." At last, after many delays, much thought and labour,

"many headaches and more heart-aches," he had the engine working satisfactorily, and at once wrote his friend and partner, Roebuck, proposing to make his long promised visit to Kinneil. The two had never met, having done all their business by correspondence. Watt added, "I sincerely wish you joy of this successful result, and hope it will make some return for the obligations I owe you."

The engine was, according to Watt himself, a "clumsy job," owing to the inexperience of the workmen; and although the model had worked perfectly, the engine itself was practically a failure, owing to clumsy workmanship. The cylinder had been badly cast, and it was found that no packing of the infinite variety which Watt tried would

keep the piston tight, and the pipe condenser arrangement worked badly. The engine was thoroughly overhauled; any improvements which suggested themselves to Watt's ever observant eye were adopted, but without success. How deep Watt's chagrin was we may gather from what he wrote to his friend, Small, on the subject:—"You cannot conceive how mortified I am with this disappointment. It is a damned thing for a man to have his all hanging by a single string. If I had wherewithal to pay the loss, I don't think I should so much fear a failure; but I cannot bear the thought of other people becoming losers by my schemes; and I have the happy disposition of always painting the worst."

The confidence of both the inventor and his patron was as strong in the principle of the machine as ever, but the chief difficulty lay in getting workmen capable of turning out the different parts of the engine with anything approaching the precision of the model, as was essential to its success. Another difficulty arose. Dr. Roebuck had sunk all his own money and much of that of many of his friends in coal mines, which, through the failure of the pumping engines, had become flooded out, and the enterprising Doctor drifted into difficulties. He was thus unable to carry out his agreement with Watt to pay the expense of the patent. In order that this important step might be taken so as to protect his claim to his great invention, Watt had again to

borrow from his unfailing friend, Dr. Black, and so drifted anew into debt for the sake of his engine.

It is interesting to see some of the side lights of those times. I cannot refrain here from looking at one. Watt, when in London, endeavouring to obtain power to construct the Forth and Clyde Canal by a route since revived—the Loch Lomond route—expressed his opinion very freely on "the confounded Committee of Parliament": "I think I shall not wish to have anything to do with the House of Commons again. I never saw so many wrong-headed people on all sides gathered together."

He was obliged to go to London to get his patent arranged, and in his then state of depression and

disappointment he doubtless had not improved his opinion of Parliamentary Committees, for we find his noble helpmeet[1] writing to cheer him, "I beg that you will not make yourself uneasy, though things should not succeed to your wish. If it (the condensing engine) will not do, something else will; never despair." He gave effect to his cheerful wife's suggestion, and recognizing the need of doing something else in order to pay his debts and maintain his wife and family, he devoted more time to his profession of civil engineering, or surveying as it was then called. In this he, as usual, exhibited such close observation, clear judgment, and subtle and inventive thought, that he not only secured plenty of work, but

[1] Margaret Miller whom he had married in 1794.

formed a reputation for ability in this direction also, which remained with him through life; so that, even after his retirement from active business life, he was induced by his old friends in Greenock to assist them by his wise counsel in the enterprises and improvements of his native town. His labours in this direction, at the time of which I now write, soon secured the object he had in view, as we find him writing again to Dr. Small, "Supposing the engine to stand good for itself, I am able to pay all my debts and some little thing more, so that I hope in time to be on a par with the world." Besides this his outdoor exercises in connection with this surveying business had raised his spirits and improved his health.

It is interesting to know some of the work with which Watt was entrusted. The authorities of Glasgow employed him to survey a canal—the Monkland—for connecting Glasgow with a neighbouring coalfield, and the Forth and Clyde Canal, as well as to make a survey of the Clyde, with the object of deepening the channel of the river. He made many other surveys not connected with the district, amongst others for the Caledonian and Crinan Canals; for a canal between Perth and Coupar-Angus through Strathmore; and he drew the plan of Hamilton Bridge, which he thus describes in writing to Small: "I have lately made a plan and estimate of a bridge over our river Clyde, eight miles above this; it is to be of five arches and 220 feet water-

way, founded upon piles on a muddy bottom."

The bridge was begun in 1771, and completed in 1780. All this time he was producing numerous minor inventions, but spent sleepless nights and sad and depressing days in thinking of his engine, always adding some improvement more or less important; and it is characteristic of the quiet perseverance and modest but strong resolution of the man that, during these dark and dreary days, he acquired the knowledge of French and German in order to read some scientific books which had not been translated.

Another side-light I would like to show is on the remuneration paid to such eminent men in those "good old times." Watt, for acting as

superintendent of the construction of the Monkland Canal, received a salary of £200 per annum. From the Commissioners of Forfeited Estates he received for his survey of the Strathmore Canal, mentioned above, the miserable pittance of £80, though the canal was to run through forty miles of rough country, and occupied his time for fully forty-three days, and it was expressly stated that this munificent sum should include his expenses. One more instance to show the thrifty habits of the city fathers in those times. Things are said to have changed since then, and references are now oftener made to other influences than that of thrift. Be that as it may, the authorities of Hamilton had decided to build over the Clyde

the bridge already referred to, and had agreed to employ the famous engineer Smeaton; but Smeaton wanted £10 for his services, and as Watt's charge was to be only £7 7s. he received the appointment. Notwithstanding that Watt was getting "on a par with the world" he was again passing through dark experiences. The exposure to the bleak weather, drizzling rains, and snell piercing winds, during his Highland surveys, was beginning to tell on his fragile frame. Roebuck had been obliged to put his all into the hands of his creditors, which also depressed Watt greatly. "My heart bleeds for him," were Watt's pathetic words, "but I can do nothing to help him. I have stuck by him indeed till I have hurt myself." To add to all his

dismay, Watt was summoned home from one of his dreary Highland surveys by the intelligence of the serious illness of his heroic wife, and arrived only to find that that noble heart had ceased to beat. She had died in childbirth. His sensitive soul was deeply stirred; he tells Small that for long afterwards he paused at the door of his house before he could gather courage to enter, since he would meet no more "the comfort of his life." Still, in this case, at least, he saw a fringe of silver lining, for he says to the same friend, "Yet this misfortune might have fallen upon me when I had less ability to bear it, and my poor children might have been left suppliants to the mercy of the wide world." The German proverb says

truly "Wenn die Noth am Grössten ist die Hilfe am Nächsten" (When need is greatest help is nearest). A truth tersely expressed in our own saying, "The darkest hour is before the dawn." So Watt experienced. Matthew Boulton of Soho, Birmingham, for whom Watt had already made plans, designs, and specifications, was drawn to look into the "steam engine," and agreed to take it up vigorously in conjunction with its inventor. So to Watt's weary gaze the day began "to break and the shadows to flee away."

CHAPTER VI.

WATT AND BOULTON.

It seems impossible to overestimate the value of Boulton's assistance to Watt. Watt had no money with which to carry out his darling project, and Boulton brought him the necessary means. More important still, Watt could find no workmen sufficiently skilful to turn out the details of his engine with anything approaching the precision necessary to success. Boulton had around him an army of skilled and experienced

artizans who could be thoroughly relied upon to turn out satisfactorily any piece of mechanism; and last, but not of less importance, Boulton, bringing a mental stimulus to Watt by the cheerful and inspiring influence of his generous nature, often lifted his over-sensitive partner from his fits of severe depression and gloom, and "stole away their sadness ere he was aware." They were perfectly fitted for each other, the one possessing in an almost absolute degree the qualities in which the other was deficient. Indeed it does not seem too much to say that but for Boulton's timely and efficient aid the completion of Watt's great invention of a separate condensing engine might have stood over for another generation, and have been

left to other hands and its name associated with another than that of its illustrious inventor. This remarkable man was born at Birmingham in September, 1728, and was therefore about eight years older than his partner. Active, energetic, enterprising, and ambitious not to accumulate wealth but to be the most perfect manufacturer of anything he undertook, he commenced active life at the early age of seventeen, and, by his inventive genius, and the thoroughness with which he grasped the details of everything he touched, he soon attained a high position in the manufacturing world. When little over thirty years of age he had earned sufficient money to enable him to retire from business; but instead of doing so he bought a

tract of waste land near Birmingham and built upon it the afterwards famous Soho Works. It would be foreign to my subject to enumerate the various objects of iron and steel which passed through his great works, from buttons, chains, buckles, and such like ornamental articles to which he applied his new mode of inlaying with steel, up to heavy ornamental works. All these were designed with great taste, judicious and artistic beauty, and executed with such perfect skill that they soon became famous all over Europe and redeemed Birmingham from the prejudice which had already then been entertained against it for its manufacture of shoddy.

In 1788 he set up the most perfect coining works then in existence,

making medals for most countries and coinage for many.

Of a generous disposition, he entertained in the most princely manner, was visited by the learned and the great, including the British Sovereign, and by princes, philosophers, statesmen, men of science, and artists, and many of the crowned heads of Europe. "The Empress of Russia," wrote Boulton to Watt, "is in my house, and a charming woman she is." She afterwards sent him her portrait as a mark of her appreciation, as also did the Emperor Paul, one of his visitors. In the midst of all his difficulties he practised his courtly hospitality as though he had no cares. He gave to his London agent as a reason for being a day late in sending some goods: "I had

lords and ladies to wait on yesterday; I have French and Spaniards to-day, and to-morrow I shall have Germans, Russians, and Norwegians."

Seldom dejected, though often in sore trouble, he finally achieved perfect success, and continued to enjoy the fruits of his well-earned triumph as well as the respect and love of all who knew him until his death, which occurred in the autumn of 1809. He was possessed of a noble nature, undaunted courage, resolution, and untiring perseverance, exceeding and unvarying cheerfulness, even under circumstances that would have cast down the hearts of other men. Fond of children and domesticity, he was a welcome guest wherever he appeared, whilst his own home was the haven of his deepest joys. Here

is a characteristic letter of this wonderful man, when in the midst of the troubles with the Cornish mine owners in November, 1782:

"I don't know a man in Cornwall amongst the adventurers but what would think it patriotism to free the mines from the tribute they pay to us, and thereby divide our rights amongst their own dear selves. Nevertheless, let us keep our tempers, and keep the firm hold we have got; let us do justice, show mercy, and walk humbly, and all, I hope, will be right at last."

I give one example more showing him in his relation to his son (his future partner), who, having been sent to Paris to perfect his knowledge of French, seemed to be spending more money than his father thought to be

for his good. His father, evidently filled with anxiety if not some alarm, asked him to keep an account of his expenses, which he must balance exactly. He urged the youth to "keep out of bad company," adding, in words that might be painted in letters of gold, "The future reputation and happiness of your life depend upon your present conduct. I must therefore insist that you do not go strolling about Sodom and Gomorrah under any pretence whatever. . . . It will not be pleasant to you to read this, but I must do my duty to you or I shall not satisfy my own conscience. I therefore hope you will do your duty to yourself, or you cannot do it to me. There is nothing on earth I so much wish for as to make you *a man*—a good man, a use-

ful man, and consequently a happy man."

Indeed, had the whole country been searched, a better partner in every respect could not have been found for Watt.[1] Already, in the days of the Kinneil engine, negotiation had been entered into between Dr. Roebuck and Boulton for a share by the latter in the new engine. Watt had made a visit to Birmingham, in 1767, on his return from his Monkland Canal Parliamentary visit, and, although he had not the advantage of meeting Boulton, he was shown over the works by their

[1] I regret that the subject of this book and the space at my disposal do not permit me to give more details as to the life of this remarkable and princely man. To those who would become better acquainted with him I recommend Dr. Smiles's famous book on Boulton and Watt.

mutual friend, Dr. Small, who was then settled as a physician in Birmingham. He was much struck with the skill of the workmen, and with the precision with which they carried out their work, and evidently felt the great advantage of an arrangement with such a man surrounded by such workmen; so in April, 1769, he wrote to Dr. Small:

"Seriously, you will oblige me if you will negotiate the following affair:—I find that, if the engine succeeds, my whole time will be taken up in planning and erecting Reciprocating engines, and the circulator must stand still unless I do what I have done too often, neglect certainty for hope. Now, Mr. Boulton wants one or more engines for his own use. If he will make a

model of one of 20 inches diameter at least, I will give him my advice and as much assistance as I can. He shall have liberty to erect one of any size for his own use. If he should choose to have more the terms will be easy, and I shall consider myself much obliged to him. If it should answer, and he should not think himself repaid for his trouble by the use of it, he shall make and use it until he is repaid. If this be agreeable to him let me know, and I will propose it to the Doctor (Roebuck), and doubt not of his consent. I wish Mr. Boulton and you had entered into some negotiation with the Doctor about coming in as partners. I am afraid it is now too late; for, the nearer it approaches to certainty, he grows the more tenacious of it. For my part I

shall continue to think as I did, that it would be for our mutual advantage." But Dr. Roebuck's terms were such that Mr. Boulton would not join in the enterprise. Dr. Small urged Watt again to visit Birmingham and see Boulton personally. Instead of Watt, however, Roebuck went, and how anxious Watt was to secure Mr. Boulton's inclusion in the enterprise we may gather from another letter to Dr. Small in September, 1769, *i.e.* during the time of Dr. Roebuck's visit. He writes thus to his friend Small:

"As for myself, I shall say nothing; but if you three can agree among yourselves, you may appoint me what share you please, and you will find me willing to do my best to advance the good of the whole; or, if this (the

engine) should not succeed, to do any other thing I can to make all amends, only reserving to myself the liberty of grumbling when I am in an ill humour."

The genuine unselfishness shown by Watt in this letter did not lead to any practical agreement being made. Meantime, Watt had been spending money on fresh inventions and new experiments, whilst his sojourn of some six months or more at Kinneil had brought him in nothing, and he found himself again drifting into debt, which compelled him to return to his surveying business, and, to that degree, neglect the engine. Thus in September, 1769, he writes to Dr. Small:

"I would not have meddled with this (the survey of the river Clyde

for the Glasgow Corporation) had I been certain of being able to bring the engine to bear. But I cannot, on an uncertainty, refuse every piece of business that offers. I have refused some common fire engines, because they must have taken my attention so up as to hinder my going on with my own. However, if I cannot make it answer soon, I shall certainly undertake the next that offers, for I cannot afford to trifle away my whole life, which, God knows, may not be long. Not that I think myself a proper hand for keeping men to their duty, but I must use my endeavours to make myself square with the world, though I much fear I never shall."

By and by, as we have seen, Dr. Roebuck's affairs had gone into

liquidation, and Boulton, who was a creditor for a considerable amount, was willing to accept Roebuck's two-third share in the engine in payment of his claim, an arrangement which the other creditors very gladly accepted, as its value had been set down at nil, such was their estimate of the worth of that asset, and Watt himself, pessimistic as ever, at least outwardly, whatever gleam of hope and confidence he felt inwardly, as to the *ultimate* success of his invention, said it was "only paying one bad debt with another." However, for weal or woe these two men of genius were united in the great enterprise, and Boulton wrote Watt in March, 1773, that he was certainly not sanguine of its success, but would assay it

and try how much gold it contained—referring to his capacity of assayer,—adding: "The thing is now a shadow; 'tis merely ideal, and will cost time and money to realize it. We have made no experiment yet that answers my purpose, and the times are so horrible throughout the mercantile part of Europe, that I have not had my thoughts sufficiently disengaged to think further of new schemes."

Watt was for many reasons "heart sick," as he said, of his then position, and decided to remove to Birmingham, where he was assured by his trusty mentor, Dr. Small, and other friends that, even should the engine really prove a failure, abundance of other employment would flow to him. Besides, Boulton earnestly in-

sisted on his speedy settlement near Soho as, apart from the manufacture of engines "for the whole world," he was in sore straits for motive power to drive his own machinery, which indeed was one of his chief reasons for embarking in the enterprise, and so for Birmingham Watt set out and got to work in May, 1774.

Before leaving Scotland the Kinneil engine had been taken to pieces by Boulton's own workmen under Watt's superintendence and transported to Soho. There it was speedily reconstructed, and, as Watt had anticipated, the handling by skilled workmen of the different pieces resulted in the engine working more satisfactorily than ever before. Watt was undoubtedly cheered

by this success, though, as ever modest in expression, he merely wrote to his father: "The business I am here about has turned out rather successful; that is to say, the fire-engine I have invented is now going, and answers much better than any other that has yet been made; and I expect that the invention will be very beneficial to me."

Under the stimulating encouragement of this success Watt worked at further improvements, but the partners were soon made painfully aware of a new and serious condition of affairs. Nearly half of the fourteen years for which the patent had been taken out had already expired, and it was felt that several years more might elapse ere the engine was perfectly complete and

successful. Meanwhile the demand from the mines, especially for more powerful and economical pumping power, had become so clamant that everyone with a bent for invention was seduced into turning his faculties in that direction. The less scrupulous did not hesitate to pirate Watt's engine, whilst one of the least scrupulous, a certain Hatley, one of Watt's Carron workmen, was base enough to steal the working drawings of the Kinneil engine and sell them for a considerable sum, and was now engaged in bringing out and selling engines differing but little from those of Watt. Face to face with this new danger, the partners decided to extend the patent or take out a new one, and with this object in view Watt proceeded to London

in the beginning of the following year (1775). Here he consulted his patent agents, tried to get orders for the firm's engines, and examined the various examples of machinery at work. On the first two points we find him writing to his partner on the 31st January, 1775: "I have a prospect of two orders for fire-engines here, one to water Piccadilly, and the other to serve the south end of Blackfriars Bridge with water. I have taken advice of several people whom I could trust about the patent. They all agree that an act would be much better and cheaper, a patent being £130, the Act, if obtainable, £110. The present patent has eight years still to run, bearing date January, 1769. I understand there will be an almost unlimited sale for

wheel-engines to the West Indies, at the rate of £110 for each horse's power."

Doubtless he had opportunities of seeing some of the engines already in use, but in some cases he found that "the fellow told me lies." He returned, tired "with running from street to street," and, laying before Boulton and Small the result of his visit, it was finally resolved to apply for a Bill. Back again he went to London to see about the Bill, which was introduced into Parliament on the 28th of February, 1775. His opinion of Parliamentary men was little likely to be heightened by his new experience. The proposed Act met with severe opposition. The mine owners were in desperation for an engine to clear their drowned-out

mines from water, and had been expecting to have this accomplished by Watt's invention; but foreseeing that, if the patent were to be prolonged by Act of Parliament, it would interfere with their free use of it, they raised the cry of "No monopoly" without any consideration for the inventor, the fruit of whose brain alone the engine was, which had cost him years of thought, sore labour, and not only all his own earnings, but also large sums from his friends. Watt, with all his modesty and retiring disposition, had a quiet but firm resolution, and drew up a statement for distribution among the members of the House, which I quote, instead of describing the points at issue. He said:

"The inventor of these new

engines is sorry that gentlemen of knowledge, and avowed admirers of his invention, should oppose the Bill by putting it in the light of a monopoly. He never had any intention of circumscribing or claiming the inventions of others; and the Bill is now drawn up in such a manner as sufficiently guards those rights, and must oblige him to prove his own right to every part of his invention, which may at any time be disputed. If the invention be valuable, it has been made so by his industry, and at his expense; he has struggled with bad health and many other inconveniences to bring it to perfection, and all he wishes is to be secured in the profits which he may reasonably expect from it—profits which he cannot obtain without an

exertion of his abilities to bring it into practice, by which the public must be the greatest gainers, and which are limited by the performance of the common engines; for he cannot expect that any person will make use of his contrivance unless he can prove to them that savings will take place, and that his demand for the privilege of using the invention will amount only to a reasonable part of them. No man will lay aside a known engine, and stop his work to erect one of a new contrivance, unless he is certain to be a very great gainer by the exchange; and if any contrivance shall so far excel others as to enforce the use of it, it is reasonable that the author of such a contrivance should be rewarded."

This statement had the desired effect, and the Act extending the patent for further twenty-four years was passed in May of the same year. Watt, "heartily sick of this town," as he wrote Boulton, at once returned to Birmingham and speedily set about arranging for the manufacture of the engines for which they had already received orders. He found his partner in splendid spirits. The engine had been fitted with a cast-iron cylinder instead of the tin one used at Kinneil. The famous iron-founder, John Wilkinson of Bersham, had hit upon a plan for boring out the cylinder with precision, and the engine at last worked to the satisfaction of all. The first new engine finished at Soho was to the order of Mr. Wilkinson himself. Watt

exerted his utmost care and skill in producing the plans, and superintended their carrying out with all his judicious solicitude.

"The Saxon cause rests on *thy* steel," said the Highland chief to the disguised monarch, so here the cause, the future existence of this costly enterprise, lay upon this single engine.

Mine owners suspended arrangements for new pumping machinery; numerous iron manufacturers who were about to erect Newcomen's engines postponed their orders until the result of this new engine was made manifest. All eyes, in short, were turned to this operation at the Soho works with the eagerness of self-interest. At last the various parts of the engine were packed and sent

to Wilkinson's works at Brossley, and erected early in 1776. Watt became anxious, if not nervous, as the work approached completion, and would have made some private trials of it; but Boulton urged him to take plenty of time, not to allow a single turn until everything was absolutely ready, adding, "Then, in the name of God, fall to and do your best."

Watt's careful planning and judicious execution were amply rewarded. The engine was a complete success, working not only to the satisfaction but to the admiration of all beholders, and the names of Boulton and Watt at once became famous. Order followed upon order in rapid succession and in increasing number, and Mr. Boulton's ambition as

embodied in his claim during the Roebuck negotiations was reached. They were "making engines for the whole civilized world." (See Fig. 6.)

CHAPTER VII.

SUCCESS AND TRIUMPH OF BOULTON AND WATT.

ORDERS continued to be booked in rapid succession. Even when Watt visited Glasgow in the summer of 1776 to bring home his second bride, he obtained several orders, one for Torryburn colliery, Fife; one for Sir Archibald Hope's colliery, near Edinburgh; another for Leadhills, and so on; nor had Boulton less favourable news to communicate in this respect. He reported inquiries for large engines for dis-

tilleries in London and Bristol, and collieries in Wales, and, writing from London, whither he had been obliged to go respecting an action against Watt, raised for infringement of an invention by a certain Mr. Humphrey Gainsborough, a dissenting minister residing at Henley-on-Thames, he said:

"Gainsborough hath appointed to meet me at Holt's, his attorney, on Monday, when I shall say little besides learning his principles and invention. If we had a hundred wheels (wheel-engines) ready made, and a hundred small engines, like Bow engine, and twenty large ones executed, we could readily dispose of them. Therefore, let us make hay while the sun shines, and gather our barns full, before the dark cloud of

age lowers upon us, and before any more Tubal Cains, Watts, Dr. Faustuses, or Gainsboroughs arise with serpents like Moses's to devour all others. . . . As to your absence, say nothing about it. I will forgive it this time, provided you promise me never to marry again." This characteristic letter will show the flourishing state of their order book, and the prospects for the future.

Boulton had before him, however, another enormous field for the use of the engine, and that was in the mines in Cornwall, many of which had been drowned out, and were useless until they got engines sufficiently powerful to do the work in which Newcomen's best machinery had completely failed. Many of the mine owners had long been in correspondence with Boulton,

who, now that he had Watt, with his successful engine, invited his correspondents to go and see for themselves what could be done at Soho. The result was many inquiries and several orders, the first two being for Wheal Busy Mine, near Chacewater, and Tingtang, near Redruth. On the success of these two the opening up of that whole district depended, so Watt himself proceeded to superintend the erection, in order that "no stone might be left unturned" to ensure success.

Watt used every care with his work, as can easily be supposed, but his experiences of the rough people of the place were not congenial to his over-sensitive and retiring nature. Indeed, he would have quickly returned to Birmingham from such

unpleasant surroundings but for the great prospect which the success of these two pioneer engines held out. Thus he wrote: "Ales and Cakes" (one of the many odd names by which the Cornish mines were called) "must wait the result of Chacewater: several new engines will be erected next year, for almost all the old mines are exhausted, or have got to the full power of the present engines, which are clumsy and nasty, the houses cracked, and everything dropping with water from their cisterns."

He, however, had formed a poor opinion of those with whom he had to deal. We find him writing: "Certainly they have the most ungracious manners of any people I have ever yet been amongst." At

the first meeting of the Wheal Virgin adventurers, with the exception of a few gentlemen, he thought "the bulk of them would not be disgraced by being classed with Wednesbury colliers." Their malice and untruthful reports filled him with disgust.

"We have been accused of working without leather upon our buckets, and making holes in the clacks in order to deceive strangers. . . . I choose to keep out of their company, as every word spoken by me would be bandied about and misrepresented. I have already been accused of making several speeches at Wheal Virgin, where, to the best of my memory, I have only talked about eating, drinking, and the weather. The greater part of the adventurers at Wheal Virgin are a mean, dirty

pack, preying upon one another, and striving who shall impose most upon the mine."

At length the decisive day arrived when the Wheal Busy engine was to be started, and the engineering and mining "world and his wife" were there to see. "All the world are agape to see what it can do," said Watt, whilst, according to his account, and indeed from the proclaimed prejudice and hostility of some, it is evident that no tears would have been shed had it failed; but again the fickle goddess spread her sheltering wings over the inventor's work, and its triumph was complete both in power and consumption of coal. Watt wrote: "We have had many spectators, and several have already become converts.

I understand all the West Country Captains are to be here to-morrow to see the prodigy." The result only spread its fame. Even those who had abjured Boulton and Watt and all their works at the commencement of the undertaking, now joined in the pæan of praise. Indeed we can see from "the light-horse trot" of Watt's letter that the impression made by the engine was profound:

"The velocity, violence, magnitude, and horrible noise of the engine give universal satisfaction to all beholders, believers or not. I have once or twice trimmed the engine to end its stroke gently, and to make less noise; but Mr. Wilson cannot sleep unless it seems quite furious, so I have left it to the engine-men; and, by the by, the noise seems to

convey great ideas of its power to the ignorant, who seem to be no more taken with modest merit in an engine than in a man." And a few days later he said: "The voice of the country seems to be at present in our favour, and I hope will be much more so when the engine gets on its whole load, which will be by Tuesday next. So soon as this is done I shall set out for home."

The firm was now overwhelmed with applications for engines, and the works were kept at high pressure, but all was not sunshine. Indeed, in many respects the shadows were heavy, and again and again enshrouded Watt in deep gloom. He had to contend against the drunkenness and unskilfulness of many of his workmen, whilst so many of the

foreign visitors tried to tempt good workmen to leave Soho for their works abroad that Watt, in his irritation, threatened to allow no foreigner or stranger into the works unless he had an order for an engine. Boulton, however, kept his head above the depressing atmosphere—kept basking in the sunshine and cheered his partner with all the influence of his strong and kindly nature. His letters to Watt abound in cheering and heartening sentences. "If our spirits don't fail us, I think our engine won't," was the strain he continued to sing to his sensitive and pessimistic partner.

They had fought and overcome prejudices so strong that, as we have seen, some of the leading engineers would have nothing to do with

machinery where these two inventors were in any way concerned. This evil having been thoroughly overcome, annoyances arose in an exactly opposite direction. No sooner was the success of the partners indisputable than others sought to secure the fruit of their genius, thought, and labour. No doubt invention had been in the air for many years, and several inventors had done creditable work, but the final successful outcome of their labours had been the adaptation of Watt's inventions with some slight alterations. Some compromised with the inventors, others would not; and the whole influence of the Cornish mine owners was against Boulton and Watt, as they thought if the patent were set aside they would get rid of

their liability for royalty. The old feud, in short, which was started when the Bill granting the patent was in Parliament, was again revived. This struggle was as severe as that of overcoming prejudices had been and it lasted for some twenty years.

I will here anticipate the thread of the narrative so far as to tell the result of the contest. About the year 1787, as we shall see, the financial position of the concern had greatly improved, and the partners determined to defend their rights, although the patents had only a few more years to run; even Watt, with all his mildness of character, felt this course to be absolutely necessary. He wrote to Boulton in March, 1796: "The rascals seem to have been going on as if the patent were

their own. . . . We have tried every lenient means with them in vain; and since the fear of God has no effect upon them, we must try what the fear of the devil can do." They experienced to the full the law's delay, for it was not until January, 1799, that judgment was delivered, but *it was a decision* when it was delivered, as Watt wrote to his partner: "We have won the cause hollow. All the Judges have given their opinions carefully in our favour, and have passed judgment. Some of them made better arguments in our favour than our own counsel, for Rous's speech was too long and too divergent. I most sincerely give you joy."

No time was lost in collecting the arrears, and large sums were speedily

gathered into the coffers at Soho, although twelve years earlier they had been enabled to make better conditions as to the prices and mode of payment of their engines. Thus they overcame their last, and to Watt most depressing difficulty, the want of money and the crushing sense of heavy debts. This turn of fortune had given Watt courage to carry on the struggle to the successful termination which I have just described, and I resume the thread of the story to show the efforts with which, and the conditions under which the strife had been waged. The mode of payment was generally a certain proportion of the savings as royalty, with such other payments as should be agreed upon. They had to take

shares in mining ventures, and they took payment in copper, and in this way large sums of money were speedily locked up. They required an an enormous amount of ready money, and Boulton, hopeful and confident as ever, being satisfied that time would soon put them in funds, had again strained every nerve to finance the undertaking. He sold and mortgaged his own property, raised money on his wife's property, borrowed from friends, and overdrew at his Bank, and showed that spirit of determination and courage which so often had saved the enterprise. On Watt the idea of the heavy debt hanging upon them was distracting, and instead of encouraging his partner, it must be confessed he allowed himself to be so downcast as to write peevish

letters to him. Thus in January, 1779, he writes:

"The thought of the debt to Lowe, Vere & Co. lies too heavy on my mind to leave me the proper employment of my faculties in the prosecution of our business; and, besides, common honesty will prevent me from loading the scheme with debts which might be more than it could pay." And a couple of years later, such was the effect of having allowed the dread of debt to prey on his mind that, in reply to a cheery letter from his partner, coaxing him to finish some work, he replied in June, 1781:

"When I executed the mortgage my sensations were such as were not to be envied by any man who goes to death in a just cause; nor has

time lessened the acuteness of my feelings. . . . I thought I was resigning in one hour the fruits of the labour of my whole life,—and that if any accident befell you or me, I should have left a wife and children destitute of the means of subsistence, by throwing away the only jewel Fortune had presented me with. . . . These transactions have been such a burden upon my mind that I have become in a manner indifferent to all other things, and can take pleasure in nothing until my mind is relieved from them; and, perhaps, from so long a disuse of entertaining pleasing ideas, never may be capable of receiving them any more."

But notwithstanding his depression of spirits and almost despair, notwith-

standing his "headaches and heart-aches," which he protested made him incapable of inventing, he still invented. He could no more refrain from inventing than Robert Burns could from writing songs. Each was a genius born, and the respective works sprang

> "from the heart
> As rain from the clouds in summer,
> Or tears from the eyelids start."

At no time during a long and toilsome life were better proofs given of the calm energy, the self-reliant wisdom, and quiet but unflagging perseverance of this marvellously many-sided man. Despite the frailty of his frame and melancholy of spirits, his inventive thoughts seemed to be always brooding on the development of steam power. The value of the

expansive quality of steam had been in his mind. He only put it to the test in 1779, in Soho, by cutting off the steam before the full stroke of the piston had been made, allowing the expansive power of the vapour to finish the process; but the carelessness and unskilfulness of the workmen make its complete adoption impracticable, though we find him a couple of years later saying in a letter to his partner, "I believe a well regulated expansion machine is the *ne plus ultra* of our art." This is one of the few directions in which his inventions have progressed beyond what could have been even his fondest dreams, and if there be any truth in the philosophy that the spirits of the departed are still cognizant of what is passing here below,

his great soul must rejoice to see kindred spirits developing the discovery so far as double and triple expansion engines.

Invention after invention proceeded during the next few years from his fertile brain in regular and brilliant succession, and startling rapidity.

In 1782, being compelled to secure circular motion without using the crank, from which he was debarred by a patent secured by a Mr. Pickard —full details having been unwittingly betrayed to him by Watt's pattern maker while drinking in a public house,—Watt devised various methods, using wheels for the purpose, but the honour of inventing the real "Sun and planet motion" belongs to William Murdoch, Watt's faithful and gifted right-hand man. Watt wrote of it,

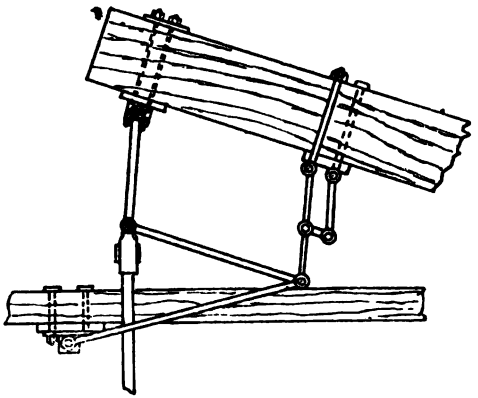


FIG. 8.—PARALLEL MOTION.

"It has the singular property of going twice round for each stroke of the engine, and may be made to go oftener round if required without additional machinery."

In the same year the problem of obtaining rotary motion by steam power was solved by Watt and applied successfully both to a tilt hammer and a corn mill, for although he seems to have had doubts as to its financial success, the regularity of action, the speed, power, and economy pushed its way, and orders soon came in apace.

Two years later (1784) we find him taking out a patent for the application of the steam engine to various machines, exhibiting such beauty and usefulness that he was now undoubtedly the lord and leader

of steam power in the world. The tilt hammer, carriages for goods and passengers drawn by steam engines, and the employment of steam in various other directions were embodied in this new patent, but the most important was the parallel motion now for the first time disclosed to the world. Watt was greatly elated by this invention, saying: "Though I am not over anxious after fame, yet I am more proud of the parallel motion than of any other mechanical invention I have ever made." (See Fig. 8.)

Watt did not seem to care about proceeding further with his "locomotive for the transport of goods and passengers," though this was the chief object advocated by his friend Robison, when he first advised him

to turn his attention to steam. William Murdoch, however, had also turned his attention to this question, and wiled away his leisure hours by constructing a large working model, with which on a certain summer day in that year he nearly frightened to death a village pastor, simple man, who met the hissing and panting fiery monster as he was indulging in a country stroll. As soon as Watt heard of Murdoch's successful trial, he wrote Boulton to prevent Murdoch proceeding further in that direction, which accordingly was done. This and one or two other matters have led some to say that Murdoch was the real author of many of Watt's inventions, and that Watt was really jealous of his assistant's unquestionable ability and quick

and thoughtful intelligence. As to the first suggestion, though Murdoch was a great mechanical genius with an active brain, and, like Watt himself, thoroughly eaten up with zeal for mechanical inventions, as shown by the sun and planet motion, the oscillating engine, an arrangement for the proper boring of cylinders, lighting by gas and numerous other beautiful inventions, it has only to be stated, in order to show the groundlessness of the accusation, that Murdoch did not enter Boulton and Watt's employment until 1779, when Watt's great invention and others were already accomplished achievements, and that most of Watt's further triumphs were obtained when Murdoch had been absent from the works. As to the suggested jealousy of Watt, such

a feeling was foreign to his whole nature, and is further disproved by the estimation in which Murdoch was held by him. "Send William to ——" here, there, and everywhere—was constantly in Watt's instructions when anything went wrong, and the unswerving loyalty with which this estimation was returned proves that the reason for Watt's present course with regard to Murdoch and his locomotive experiment was the one he gave—that it would distract his thoughts from his multifarious and onerous duties.

The account of William Murdoch's engagement by the firm is interesting. The young Scotsman called at Soho and asked Boulton for a job, but was told that trade was too slack. Like most young country lads—for he be-

longed to Bellow Mill near Old Cumnock, Ayrshire—he was "blate" in the presence of strangers, and kept twirling his hat in his hands. This hat seemed of a strange substance and shape, and Boulton's attention being attracted by it, he said, "That seems a strange sort of a hat," examining it. "Why, what is it made of?" "Timmer, sir," said he quietly. "Timmer! Do you mean to say it is made of wood?" "Yes, sir." "Pray, how was it made?" "I turned it mysel, sir, in a bit lathey of my own making." Good, William Murdoch, this is worth a thousand written certificates!! "By their deeds shall ye know them." "You may call again, young man." "Thank you, sir," likely with another twirl of the hat. He became, as we

have seen, not only the right-hand man, but a most trusty right-hand man in the famous firm of Boulton & Watt.

In 1782 Watt's observant and reflective mind discovered the composition of water. In this matter he felt himself aggrieved. He had his thoughts turned to this subject by the trials of his friend, Dr. Priestley, and made several experiments to solve the problem. He wrote to Boulton in 1782 as follows:

"You may remember that I have often said that if water could be heated red hot, or something more, it would probably be converted into some kind of air, because steam would in that case have lost all its latent heat, and that it would have been turned wholly into sensible heat,

and probably a total change of the nature of the fluid would ensue. Dr. Priestley has proved this by experiment. He took lime and chased out all the fixed air, and made it exceedingly caustic by long-continued and violent heat. He then added to it two ounces of water, and as expeditiously as possible subjected it again to a strong heat, and he obtained two ounces' *weight* of air; and, what is most surprising, a balloon which he interposed between the retort and the receiver was not sensibly moistened, nor at all heated that could be observed. The air produced was but very little more than common air, and contained scarce any fixed air. So here is a plain account of where the atmospheric air comes from. The

doctor does me justice as to the theory."

Watt wrote a letter giving the results of his experiments to Dr. Priestley to be read in April, 1783, before the Royal Society. I give exact dates as the points in the dispute turn upon them, but he wished to see the result of Priestley's further experiments, and from this and other causes his thesis was delayed a full year, until the 29th of April, 1784. Meantime Cavendish, the great expert in pneumatic chemistry, had been led to experiment on the same problem, which he also solved and he sent a paper to the Royal Society three months earlier, viz., 13th January of that year. Watt's annoyance and indignation were extreme for one of

his gentle and charitable nature, and in the moment of his irritation he wrote to a friend on 15th May, 1784, as follows: "I have had the honour, like other great men, to have my ideas pirated. Soon after I wrote my first paper on the subject, Dr. Blagden explained my theory to M. Lavoisier at Paris; and soon after that M. Lavoisier invented it himself, and read a paper on the subject to the Royal Academy of Sciences. Since that, Mr. Cavendish has read a paper to the Royal Society on the same idea, without making the least mention of me. The one is a French financier, and the other a member of the illustrious house of Cavendish, worth above £100,000, and does not spend £1000 a year. Rich men may do

mean actions. May you and I always persevere in our integrity and despise such doings."

No doubt Watt did his brother investigator wrong. Cavendish had arrived at the solution by different experiments from those of Watt, and Watt himself seems to have become satisfied of this, for some years after, when his anger had entirely passed away and possibly had been forgotten, he wrote: "After all, it matters little whether Cavendish or I discovered the composition of water; the great thing is that it is discovered."

"Necessity," says the proverb, "is the mother of invention," and no where is this truth more clearly illustrated than in many of Watt's arrangements. Thus, at the Cornish

mines, where the firm's royalty was one-third of the saving of fuel and calculated by the number of strokes, Watt made an ingenious piece of mechanism called the "counter," which, attached to the main beam, worked automatically, and was kept inviolable under lock and key and gave its returns with indisputable precision.

In the year most fertile in inventions (1784) Watt was dissatisfied with the valve which had hitherto been used to regulate the speed of the piston, for, having to be adjusted by hand, it naturally lacked exact uniformity. This was achieved by Watt's governor, one of the most beautiful pieces of mechanism that ever left his hands. Two balls were fixed on the ends of bars or arms

connected with the engines. If too much steam were going into the cylinder the governor cut off the steam, if too little the balls came closer together, opened the valve, and admitted more steam. In this way perfect uniformity was obtained. Here (Fig. 9) is a sketch of this neat and useful mechanical contrivance, which, amidst all the extensions and improvements in steam apparatus has remained practically unchanged from the form conceived in Watt's busy brain.

His inventive genius did not stop at engines and their concomitants. As in early days he invented arrangements for curing smoky chimneys and other humble contrivances to make sweeter the experiences of daily life, so now he invented con-

trivances to do away with inconveniences whenever they appeared. The most useful and notable of these was the letter-copying press. Watt, unlike most scientific men, was a most voluminous correspondent, and he was obliged to spend a great deal of time in copying his letters, so he hit upon the contrivance of the copying-press and manufactured it in the form at use in the present day. He wrote about it to his friend, Dr. Black, on the 24th of July, 1778: "I have lately discovered a method of copying writing instantaneously, provided it has been written the same day or within twenty-four hours. I send you a specimen, and will impart the secret if it will be of any use to you. It enables me to copy all my business letters."

Then he turned his attention to the discovery of an ink suitable for use in the copying machine, in which he succeeded, and the copying press trade soon formed a separate and lucrative branch in the Soho Works, although the bankers almost to a man denounced it as sure to lead to the increase of forgery, one fiery soul expressing the charitable wish that "the inventor was hanged and the machines all burnt." Such views were the result of the influence of that direful mother and daughter, ignorance and prejudice. The general public were not so misled. Orders for these useful machines poured in both for home use and exportation.

These are only a few of the inventions which from 1778 to 1784

sprang from his teeming brain and which I have cited in order to show that in spite of his depression of spirits, "his headaches and heart-aches"—"my head is good for nothing," as he put it—his subtle and powerful brain was working energetically all the time. We have seen how the feeling of debt weighed upon him, and doubtlessly increased the pains he felt, but about this time he must gradually have begun to feel relieved on this head, for only three years later he was not only clear of debt, but had money at his credit in the bank. Boulton, with his matchless kindness and unwearying thoughtfulness, wrote to their London agent in December, 1787:

"As Mr. Watt is now at Mr. Macgregor's in Glasgow, I wish you

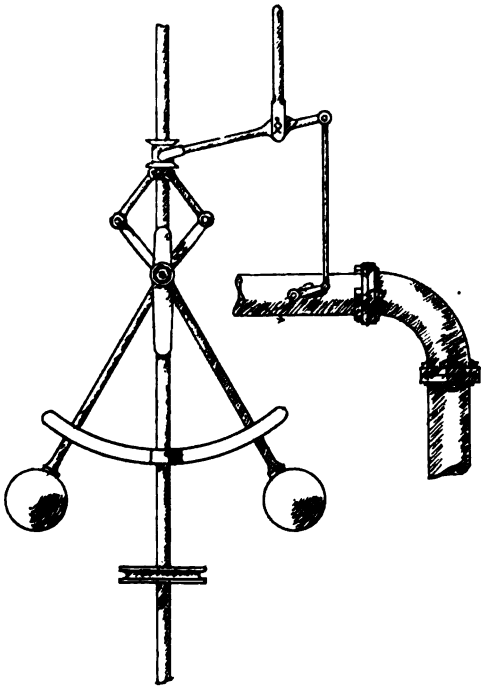


FIG. 9.—WATT'S GOVERNOR.

would write him a line to say that you have transferred £4000 to his own account, that you have paid for him another £1000 to the Albion Mill, and that about Christmas you suppose you shall transfer £2007 more to him, to balance."

I shall only refer to one other invention, and that a most important one, the double-acting engine, a rotary engine with a parallel motion. A great many hitches occurred in this important and complicated machine, and Boulton, the ever-cheery, sanguine and resolute Boulton, was dissatisfied with its first performance and wished they had remained by the single-action engine. Several letters passed between the two partners, which are interesting in the extreme. I cite

only part of one of the last from Watt to his partner dated 18th March, 1786, which runs:

"Above all, patience must be exercised and things coolly examined and put to rights, and care be taken not to blame innocent parts. Everything must, as much as possible, be tried separately. Remind those who begin to growl, that in new, complicated, and difficult things human foresight falls short—that time and money must be given to perfect things and find out their defects, otherwise they cannot be remedied."

The engine at the next trial was quite successful, but Watt's modest and retiring nature was somewhat outraged by the Albion Mill people, who sought to turn the engine-room

into a kind of show place, and he fairly burst into a fierce denunciation when he found that the managers proposed, in order to start the mill with what they thought becoming éclat, to have a large and elegant social function. In his letter of 10th March, 1786, he, writing to his partner, says: "What have Dukes, Lords, and Ladies to do with masquerading in a flour-mill? You must take steps to curb the vanity of —— else it will ruin him. As for ourselves, considering that we are much envied at any rate, everything which contributes to render us conspicuous ought to be avoided. Let us content ourselves with doing." Possibly the social function was not so obnoxious to the genial soul of Mr. Boulton, who knew the value of

such entertainments in connection with new enterprises, and to judge from his own princely hospitalities enjoyed them also.

The great and increasing demand for their engines enabled them rapidly to discharge their obligations, so that even Watt breathed freely, and the partners at last reaped the reward of all their labour, thought, and worry, being in 1787 of as high standing in a financial respect as they had hitherto been as manufacturers, whilst the judgment already referred to ultimately filled their coffers to overflowing.

In 1794 Watt's son James and Boulton's eldest son Matthew Robinson, both of whom had been liberally and judiciously educated, joined the firm as partners. The scriptural say-

ing, "Instead of the fathers will be the children," was fulfilled; and the introduction of this young blood gave a strong and healthy further onward move, so that at Soho "Peace was within her walls, and prosperity within her palaces," until the expiry of the patent in 1800, when Watt retired and the partnership of these two great men, which had altered the face of the civilized world, was dissolved. Their life's great work, or at least that part of it which has made their names immortal, had been done.

CHAPTER VIII.

CONCLUSION.

In the foregoing chapters I have tried to tell Watt's life chiefly with regard to the one great invention which ushered in a new epoch upon the world, but I desire in this concluding chapter to round off the story by a few references to his private life and character.

As regards these, the preceding chapters have given us material from which to form a fair estimate, but I wish to add a few incidents for which I could not hitherto find convenient places.

"The hand that rocks the cradle rules the world" is a saying as trite as true, and no doubt Watt's retiring and sensitive, though really strong and noble nature was largely influenced by his early home life, and by the intercourse which circumstances rendered so close and constant with his mother, a woman as we have seen of an unselfish nature and elevated character with most judicious views of daily life. Her severe domestic afflictions, together with his fragile constitution, drew out to the full her maternal fondness and watchful solicitude, which he reciprocated by his gentle and winning attentions. She was supremely happy in his companionship, and often said that even the loss of her daughter, was "fully made up to her by the thoughtful attention of

James." He spent his outdoor hours in wandering up the Leven valley—a very different valley then from now—and along the shores of Loch Lomond. He studied astronomy, and from his earliest years eagerly observed everything connected with machinery. Nor is this to be wondered at when we consider the character and tendencies of his immediate forefathers. The theoretical and the practical seemed to meet in him, as was shown in his after-life, and, falling on an age when invention was in the air, when thoughtful men of all classes were stirred in the direction of discovering a solution for the great problems of the day—the age of Arkwright, Hargreaves, and other great spirits—Watt, the most distinguished of them all, appears as

the natural product of his own and immediately preceding times.

In July, 1764, he married his cousin, Margaret Miller, a young lady of a sprightly and cheerful disposition, the very best temperament to be mated with the reflective and nervous constitution of Watt, much troubled with "headaches and heartaches," and, like his great countryman, Thomas Carlyle, greatly suffering from dyspepsia. Seldom indeed was a more desirable union. In it Schiller's beautiful picture of a married pair was fulfilled to the letter:

> " Denn wo das Strenge mit dem Zarten
> Wo Starkes sich und Mildes paarten,
> Da gebt es einen guten Klang." [1]

[1] For where the strong and the tender,
Where the firm and the mild unite,
There a harmonious peal is given.
—Schiller's *Lay of the Bell.*

How this noble woman cheered him in his depression and comforted him in his sore toil, we may judge from her encouraging and brave letters, one of which I have already quoted. As we have seen, she was not long spared to him, and how he felt the loss of her who had struggled with him through poverty and cheered him out of his melancholy, and by her smile and eloquence of gentleness "stole away his sadness ere he was aware," we can easily conceive, had he not indeed by a few words shown the depth of his feeling as he, time after time, was compelled to stand at his door before entering the house from which the "comfort of his life had gone for ever."

Like all men of strong character, he threw himself into hard work in

order to try and forget his misery. Shortly after going to Soho, he married a second time, a course to which his friends strongly advised him, as he was left with two young children—James, who eventually succeeded him at Soho, and a daughter, who married a Mr. Miller. His second wife was Miss Anne M. MacGregor, the daughter of a very cautious gentleman, who, with the canniness of his nation, insisted that Watt's deed of partnership should be signed before he gave his consent. The lady proved an excellent wife and seems from her letters to have used all her influence to cheer him during the times when the spirit of depression and melancholy was upon him, though she confessed she did not always succeed. Watt seems,

like all true men, to have tried to fight against his weaknesses so far as to make his home happy, and the picture drawn by Fanjas Saint-Fond of a visit to the great engineer's house shows that his efforts were not entirely without success. He says: "Watt joins to the frankness of a Scotchman the amiability and kindness of a man of the world. Surrounded by charming children, well educated and full of talent, he enjoys in their midst the happiness of regarding them as his friends, while he is almost worshipped by them as the best of fathers." Mrs. Watt was accustomed to keep her house in thorough order, and by and bye developed a mania for intemperance in cleanliness. There is intemperance in virtues as well as

in vices. A friend of hers tells how her very pug-dogs had been taught never to cross the threshold into the hall without first carefully wiping their little feet on the mat. Dr. Smiles on this subject says graphically and suggestively: "She hated the sight of her husband's leather apron and soiled hands while he was engaged in his garret work; so he kept himself out of her sight at such times as much as possible. Some notion of the rigidity of her rule may be inferred from the fact of her having had a window made in the kitchen wall, through which she could watch the servants, and observe how they were getting on with their work.

"Her passion for cleanliness was carried to a pitch which often fretted

those about her by the restraints it imposed; but her husband, like a wise man, submitted to her rule. He was fond of a pinch of snuff, which Mrs. Watt detested, regarding it only as so much 'dirt'; and Mr Muirhead says she would seize and lock up the offending snuff-box whenever she could lay hands upon it. He adds that at night, when she retired from the dining-room, if Mr. Watt did not follow at the time fixed by her, a servant entered and put out the lights, even when a friend was present; on which he would slowly rise, and meekly say, 'We must go.'"

Watt's great burden was his depression of spirits and his tendency to melancholy. These, there can be little doubt, were due partly to the dyspepsia from which he suffered, but

more especially to the pall which the sense of the heavy debt the firm owed threw over his nervous and sensitive nature. We see that, not only from his constant references to his sense of this intolerable burden, but in one of his wife's letters to Mr. Boulton, where this is stated with all a woman's force and charm, when springing from deep solicitude. In April, 1781, she wrote thus, "I know the goodness of your heart will readily forgive me for this freedom, and your friendship for Mr. Watt will, I am sure, excuse me for pointing out a few things that press upon his mind. I am very sorry to tell you that both his health and spirits have been much worse since you left Soho. It is all that I can do to keep him from sinking under that fatal

depression. Whether the badness of his health is owing to the lowness of his spirits, or the lowness of his spirits to his bad health, I cannot pretend to tell. But this I know, that there are several things that prey so upon his mind as to render him perfectly miserable. You know the bond that he is engaged in to Vere's house has been the source of great uneasiness to him. It is still so, and the thought of it bows him down to the very ground. . . . There is another affair that sits very heavy on his mind; that is, some old acounts that have remained unsettled since the commencement of the business. They never come across his mind but he is rendered unfit for doing anything for a long time. A thousand times have I begged him to mention them to

you. Believe me, there is not on earth a person who is dearer to him than you are. It causes him pain to give you trouble. The badness of his constitution and his natural dislike to business make him leave many things undone that he knows ought to be done, and, when it is perhaps too late, to make himself unhappy at their being neglected. . . . In his present state of weakness, every ill, however trifling, appears of a gigantic size, while, on the other hand, every good is diminished. Again, I repeat, that from the certain knowledge I have of his temper, nothing could contribute more to his happiness and make him go on cheerfully with business than having everything finished as he goes along, and have no unsettled scores to

look back to and brood over in his mind."

But even when in this state, such was the latent energy and mature wisdom of this wonderful man that when Boulton was ill and wrote in very low spirits, Watt replied, expressing his sympathy, instancing his own suffering in this direction, and adding an advice to his partner which has been stated in various forms by the highest and most select teachers in all ages: "There is no pitch of low spirits that I have not a perfect notion of, from hanging melancholy to peevish melancholy. *You must conquer the devil when he is young.*" However, within six years of the writing of this pathetic letter, Watt was, as we have seen, relieved from his intolerable burden,

and his health gradually became stronger, his spirits calmer and even cheerful, and his views of life much more pleasant, his closing years being undoubtedly the happiest of his life. Incident might be crowded on incident to show how respected or rather beloved he was by the children he took on his knee, by the young strugglers after scientific knowledge whom he was ever ready to advise and assist, as well as by the philosophers he dazzled by his talk. Even Jeffrey confessed: "It seemed as if every subject that was casually started had been that which he had been occupied in studying." Perhaps the feeling is best illustrated by an incident which occurred when Dr. Black heard of the triumphant victory in vindication

of their patent in 1799. He could not restrain his tears, giving as his apology, "It's very foolish, but I can't help it when I hear of anything good to Jamie Watt." Foolish indeed! It was a foolishness to which most who knew him yielded, as few could resist the glamour and charm of Watt's winning and commanding personality.

The happiness and peace of his closing years were no doubt greatly increased by his continuance in the exercise of the divine gift of work. For comfort's sake, owing no doubt to the peculiar cleanliness of his wife, he had a garret fitted up with a lathe, stove, and various tools, many of which were the very instruments with which he worked in his early years. Being too absorbed in his

work to go to his meals, he had a frying pan and a Dutch oven in which he cooked such food as he took. Here he peacefully carried on his inventions, no longer calling down a curse upon his inventive faculties, but quietly pursuing the even tenor of his great career. He reviewed and examined his former inventions, and took an interest in those of others. One of his fears was the loss of his mental and physical faculties as years went on, and he set himself tasks to test them; but ample proofs showed that his eye was not dim nor his natural force abated, nor had his right hand lost any of its cunning. He was consulted by the authorities of Greenock, Glasgow, and other towns for guidance in their undertakings. One of

his last and greatest inventions was a pipe joint to carry water over an uneven and shifting water bed. This he did, following, as we are told, the construction of the lobster's tail, a principle still employed amongst pipe founders.

He visited many of his old haunts, and was staying at Glenarbuck, near Dumbarton, when he received the news of the death of his partner and true friend, Boulton. He went also occasionally to London, where he spent hours in looking into the shop windows noticing the improvements made even in watchmakers' articles. A fine word picture is drawn of him by Sir Walter Scott who met him, on one of these journeys, in an assembly of distinguished men in Edinburgh when

he had reached the mature age of 82 :

"Amidst this company stood Mr. Watt, the man whose genius discovered the means of multiplying our national resources to a degree perhaps even beyond his own stupendous powers of calculation and combination; bringing the treasures of the abyss to the summit of the earth—giving the feeble arm of man the momentum of an Afrite—commanding manufactures to arise, as the rod of the prophet produced water in the desert, affording the means of dispensing with that time and tide which wait for no man, and of sailing without that wind which defied the commands and threats of Xerxes himself. This potent commander of the elements—this abridger of time and

space—this magician, whose cloudy machinery has produced a change on the world, the effects of which, extraordinary as they are, are perhaps only now beginning to be felt—was not only the most profound man of science, the most successful combiner of powers and calculator of numbers, as adapted to practical purposes,—was not only one of the most generally well-informed, but one of the best and kindest of human beings.

"There he stood, surrounded by the little band I have mentioned of Northern *literati*, men not less tenacious, generally speaking, of their own fame and their own opinions, than the national regiments are supposed to be jealous of the high character which they have won upon service. Methinks I yet see and

hear what I shall never see or hear again. In his eighty-fifth year,[1] the alert, kind, benevolent old man, had his attention alive to everyone's question, his information at everyone's command.

"His talents and fancy overflowed on every subject. One gentleman was a deep philologist, he talked with him on the origin of the alphabet as if he had been coeval with Cadmus; another a celebrated critic—you would have said the old man had studied political economy and belles-lettres all his life,—of science it is unnecessary to speak, it was his own distinguished walk. And yet, Captain Clutterbuck, when

[1] This is one of the few slips made by Sir Walter Scott. Watt died in his eighty-third year. Sir Walter should have said his eighty-second.

he spoke with your countryman, Jedediah Cleishbotham, you would have sworn he had been coeval with Claver'se and Burley, with the persecutors and persecuted, and could number every shot the dragoons had fired at the fugitive Covenanters. In fact we discovered that no novel of the least celebrity escaped his perusal, and that the gifted man of science was as much addicted to the productions of your native country (the land of Utopia aforesaid), in other words, as shameless and obstinate a peruser of novels, as if he had been a very milliner's apprentice of eighteen." . . .

Honours were sought to be showered upon him, learned societies enrolled him as a fellow; his old University of Glasgow conferred

upon him the degree of LL.D., and Lord Liverpool offered him a baronetcy, which, as not in keeping with his modesty and simplicity of character, he declined. A sheriffdom was twice offered him and declined in pathetic and touching language. He pled that he as "a timid old man" should not have a duty imposed upon him that he was totally unfit for, nor have his grey hairs weighed down with a load of vexatious cares. "My inventions," he continued, "are giving employment to the best part of a million of people, and having added many millions to the national riches, I have a natural right to rest in my extreme age." His pleas were in both cases regarded as sufficient, and he was excused.

At length the time of his departure

drew near. In 1819 he became not so much ill as unwell. The bodily machinery was fast wearing out. He was conscious of this, and calmly and peacefully expressed his gratitude to Providence for his "earthly blessings, length of days, and exemption from the usual infirmities of age." He said to his friends standing round his death-bed, "I am very sensible of the attachment you show me, and I hasten to thank you for it, as I feel that I am now come to my last illness." And so on the 19th August, 1819, in the eighty-third year of his age, the strong springs of this great life became weary and stood still.

"Mark the perfect man and behold the upright, for the end of that man is peace."

I cannot finish this sketch without again emphasizing the rich possession by Watt of that rare quality of modesty which has characterized and distinguished the highest and noblest men of genius in all ages, whose lives and teachings and achievements have showered blessings on humanity and dignified the human race, from Confucius, Buddha, and the Great Apostle, who in spite of his transcendent gifts and acquirements confessed himself even "less than the least of all saints," down to Newton, Stephenson, and the greatest scientist of the present day, our own illustrious townsman, Lord Kelvin.

A dignified "not unto me" runs like a golden thread through a letter to his old comrade Robison when he

heard of the death of that friend so staunch and true, Dr. Black, a letter also which gives further insight into his own mind and character in these his latter years. He wrote in February, 1797:

"I may say that to him I owe, in a great measure, what I am; he taught me to reason and experiment in natural philosophy, and was a true friend and philosopher, whose loss will always be lamented while I live. We may all pray that our latter end may be like his. He has truly gone to sleep in the arms of his Creator, and been spared all the regrets attendant on a more lingering exit. I could dwell longer on this subject; but regrets are unavailing, and only tend to enfeeble our own minds, and make them less

able to bear the ills we cannot avoid. Let us cherish the friends we have left, and do as much good as we can in our day!"

On another occasion, when a certain nobleman was expressing admiration at his achievements, Watt rejoined:

"The public only look at my success, and not at the intermediate failures and uncouth constructions which have served me as so many steps to climb to the top of the ladder."

Perhaps these very words may have suggested to Dr. Chalmers that eloquent outburst in his discourse on "The Modesty of True Science," in which he passes his splendid eulogy on our great scientist, with which I close, substituting the name of Watt for that of Newton and mechanic for astronomer:

"There are perhaps no two sets of human beings who comprehend less the movements, and enter less into the cares and concerns of each other, than the wide and busy public on the one hand, and, on the other, those men of close and studious retirement, whom the world never hears of save when from their thoughtful solitude there issues forth some splendid discovery to set the world on a gaze of admiration. Then will the brilliancy of a superior genius draw every eye towards it—and the homage paid to intellectual superiority will place its idol on a loftier eminence than all wealth or than all titles can bestow—and the name of the successful philosopher will circulate, in his own age, over the whole

extent of civilized society, and be borne down to posterity in the characters of ever-during remembrance; and thus it is that, when we look back on the days of Watt, we annex a kind of mysterious greatness to him, who, by pure force of his understanding, rose to such a gigantic elevation above the level of ordinary men—and the kings and warriors of other days sink into insignificance around him—and he, at this moment, stands forth to the public eye, in a prouder array of glory than circles the memory of all the men of former generations—and while all the vulgar grandeur of other days is now mouldering in forgetfulness, the achievements of our great mechanic are still fresh in the

veneration of his countrymen, and they carry him forward on the stream of time, with a reputation ever gathering, and the triumphs of a distinction that will never die."

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